SOIL SURVEY OF

Renville County, North Dakota

United States Department of Agriculture
Soil Conservation Service
In cooperation with
North Dakota Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agriculture Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1965–69. Soil names and descriptions were approved in 1970. Unless otherwise indicated, statements in the publications refer to conditions in the county in 1970. This survey was made cooperatively by the Soil Conservation Service and the North Dakota Agricultural Experiment Station. It is part of the technical assistance furnished to the Renville County Soil and Water Conservation District.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, woodland, and windbreaks; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Renville County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and shows the capability classification of each. It also shows the page where each soil is described and the page for the windbreak suitability group and the capability unit in which the soil has been placed.

Individual colored maps that show the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those that have a moderate limitation can be colored yellow, and those that have a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the descriptions of the windbreak suitability groups.

Foresters and others can refer to the section "Woodland and Windbreaks," where the soils of the county are grouped according to their suitability for trees.

Wildlife managers and others can find information about the use of soils for wildlife in the section "Wildlife."

Community planners and others can read about soil properties that affect the choice of sites for recreation areas in the section "Recreation."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain estimates of soil properties and information about soil features that affect engineering practices.

Scientists and others can read about the soils in the section "Formation and Classification of the Soils."

Newcomers in the area may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information given in the section "General Nature of the County."

Cover: **Typical area of the Barnes-Hamlet association. The windbreaks are used to control soil blowing.**

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Summary of Tables

SOIL SURVEY OF RENVILLE COUNTY, NORTH DAKOTA

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

RENVILLE COUNTY is in the north-central part of North Dakota (fig. 1). It has a total area of 576,501 acres. Mohall, the principal town and the county seat, is on the east-central edge of the county.

Physiographically, the county consists of nearly level glacial till plains dissected by glacial outwash channels. The Des Lacs River cuts across the southwestern corner of the county, and the Souris River meanders from north to south through the entire length of the county. Both of these rivers have deeply entrenched valleys. Lake Darling, the only major artificial impoundment, has flooded the bottom lands along the Souris River in the southern half of the county.

The semi-arid, continental climate is characterized by cold, long, snowy winters and by summers that have warm, bright days and cool nights. The average annual precipitation at Mohall is 16.77 inches, of which about 80 percent falls during the growing season.

About 80 percent of Renville County is used for crops, mainly wheat, barley, and flax. Oats and rye are also commonly grown. The only large areas of native grass are along the breaks of the Des Lacs and Souris Rivers. Raising beef cattle is a relatively minor enterprise and is concentrated along these two rivers. Few dairy farms are in Renville County. Only a small acreage is in woodland, mainly on bottom lands and in the breaks along the Souris and Des Lacs Rivers.

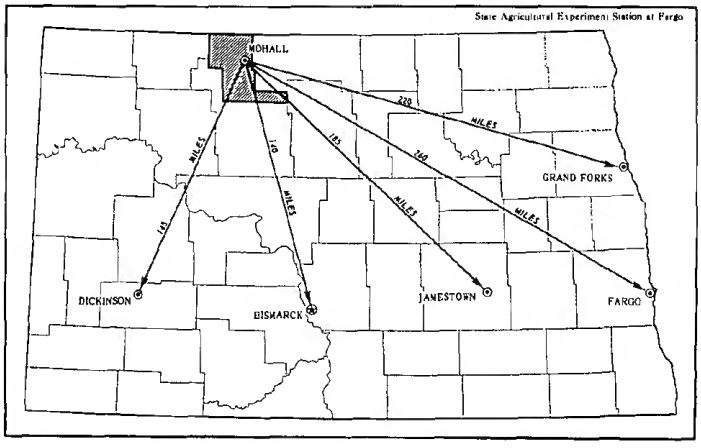

Figure 1.—**Location of Renville County in North Dakota.**

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Renville County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes; the size and speed of streams; the kinds of native plants or crops; the kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Barnes and Hamlet, for example, are the names of two soil series. All the soils in the United States that have the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Barnes cobbly loam, 1 to 6 percent slopes is one of several phases within the Barnes series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders,

trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Renville County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Barnes-Buse loams, 3 to 6 percent slopes, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Barnes and Buse very stony loams, 3 to 15 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Gravel pits is a land type in Renville County.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. Then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Renville County. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It typically consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in an association can occur in other associations, but in different patterns.

A map that shows soil associations is useful to people who want to have a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide for broad planning of a watershed, a wooded tract, or a wildlife area or for broad planning of recreation facilities, community developments, and such engineering works as transportation corridors. It is not a suitable map for detailed planning for management of a farm or field or for selecting the exact location of a road, building, or other structure, because the soils within an association ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The seven soil associations in Renville County are described in the pages that follow.

1. Barnes-Hamlet association

Nearly level, well drained and moderately well drained, medium textured soils on glacial till plains

This association consists of deep, nearly level soils that formed in glacial till. There are many small depressions.

This association covers about 75 percent of the county. Barnes soils make up about 62 percent of the association, Hamlet soils 13 percent, and minor soils 25 percent.

Barnes soils are on nearly level to slightly convex side slopes and are well drained. The surface layer is black loam about 7 inches thick. The subsoil is dark grayish-brown and dark-brown loam about 9 inches thick. The underlying material is calcareous loam glacial till.

Hamlet soils are on nearly level to slightly concave side slopes and are moderately well drained. The surface layer is black loam about 8 inches thick. The subsoil is very dark grayish-brown and dark grayish-brown loam about 11 inches thick. The underlying material is calcareous loam glacial till.

Some of the minor soils are Tonka and Parnell soils in depressions, Hamerly soils adjacent to depressions, Svea soils in swales, and Buse soils on hilltops and ridges.

Growing cash crops is the main enterprise. The soils of this association have high potential for all cultivated crops commonly grown in the county. Nearly all the acreage is cultivated. The soils are high in fertility, and the available water capacity is high. The main concerns of management are controlling soil blowing and improving drainage. Undrained wet areas are used for pasture, hay, and wildlife habitat.

2. *Swenoda-Embden-Barnes association*

Nearly level to undulating, moderately well drained and well drained, moderately coarse textured and medium textured soils on glacial till plains

This association is on loamy glacial till plains that are covered with varying depths of sandy material deposited by wind and water.

This association covers only about 1 percent of the county. Swenoda soils make up about 30 percent of the association, Embden soils 30 percent, Barnes soils 30 percent, and minor soils 10 percent.

Swenoda soils are nearly level or gently undulating, deep, and moderately well drained. The surface layer is black fine sandy loam about 9 inches thick. The upper part of the subsoil is very dark grayish-brown fine sandy loam about 14 inches thick, and the lower part is dark-brown loam about 7 inches thick. The underlying material is loam glacial till. Permeability is moderately rapid in the upper part of the soil and moderately slow in the lower part.

Embden soils are nearly level and gently undulating, deep, and moderately well drained. The surface layer is black and very dark grayish-brown sandy loam about 16 inches thick. The subsoil is dark grayish-brown sandy loam. The underlying material is loamy sand and sandy loam. Permeability is moderately rapid.

Barnes soils are nearly level to gently undulating, deep, and well drained. The surface layer is black loam about 7 inches thick. The subsoil is dark grayish-brown and dark-brown loam about 9 inches thick. The underlying material is calcareous loam glacial till.

Growing cash crops is the main enterprise. Most of the acreage of this association is cultivated. Barnes soils have a high available water capacity and are high in fertility. They have a high potential for all cultivated crops commonly grown in the county. Embden and Swenoda soils have a moderate available water capacity and are moderate in fertility. They are somewhat droughty and are subject to severe soil blowing. The soils are suited to all commonly grown crops, but rye is grown in many places because it matures early and helps control soil blowing.

3. *Fargo-Great Bend association*

Level and nearly level, poorly drained and well drained, fine textured and moderately fine textured soils in glacial lake basins

This association is in level and nearly level lake basins near Tolley.

This association covers only 1 percent of the county. Fargo soils make up about 50 percent of the association, Great Bend soils 30 percent, and minor soils 20 percent.

Fargo soils are deep and poorly drained. The surface layer is black silty clay about 8 inches thick. The subsoil is very dark gray silty clay about 22 inches thick. The underlying material is gray silty clay.

Great Bend soils are deep and well drained. The surface layer is black silty clay loam about 7 inches thick. The subsoil is very dark grayish-brown silty clay loam about 8 inches thick. The underlying material is grayish-brown silty clay loam and clay loam.

Some of the minor soils are Fargo soils and Swenoda soils. The Fargo soils are wet and in the lowermost part of the lake basins. The Swenoda soils are moderately well drained. They are on the rims of some of the lake basins.

The Fargo and Great Bend soils have high available water capacity, have high organic-matter content, and are high in fertility. Most of the acreage of Great Bend soils is cultivated, and for these soils there are few management problems. Fargo soils are cultivated where they are dry enough, but in years when spring runoff is rapid, it is not unusual for areas of Fargo soils to remain ponded for several years. It is seldom possible to artificially drain Fargo soils. If cultivated, both soils are highly productive. Fargo soils are moderately susceptible to soil blowing.

4. *Zahl-Max association*

Gently rolling to very steep, well drained, medium textured soils on side slopes of river valleys

This association is on side slopes of river valleys and on flood plains of the Des Lacs and Souris Rivers. The slope is 9 to 60 percent.

This association covers about 8 percent of the county. Zahl soils make up about 23 percent of the association, Max soils 19 percent, and minor soils 58 percent.

Zahl soils are on the convex upper side slopes of valleys. These soils are deep and well drained. The surface layer is thin and very dark brown loam about 5 inches thick. The underlying material is very dark grayish-brown and dark grayish-brown loam glacial till.

Max soils are on the less steep side slopes. They are deep and well drained. The surface layer is very dark brown loam about 4 inches thick. The subsoil is very dark grayish-brown loam about 9 inches thick. The underlying material is calcareous loam glacial till.

Among the minor soils are Velva, LaDelle, and Ludden soils. These soils are on flood plains. They are subject to occasional flooding when spring runoff overflows the river bank. The Velva soil is well-drained loam. The LaDelle soil is moderately well drained silty clay loam. The Ludden soil is poorly drained silty clay.

Some of the other minor soils in this association are Barnes, Buse, Svea, Williams, Arvilla, Renshaw, and Sioux soils. Although the minor soils make up about 58 percent of the association, no single soil makes up more than 5 percent of the total area.

About half of the acreage of this association is within the boundaries of the Upper Souris National Wildlife Refuge. Lake Darling covers much of the bottom land within the refuge. The other areas of this association are used for pasture or for recreation.

Cash-grain farming and raising beef cattle are the main enterprises. Zahl and Max soils are used for pasture. Velva and LaDelle soils are well suited to crops, and most areas are used for that purpose. They are also used for pasture, tame grass, and alfalfa. Ludden soils are often ponded in spring unless they are artificially drained. Undrained areas are used mainly for hay, and drained areas are used for crops, tame grass, and alfalfa.

5. *Barnes-Colvin association*

Nearly level, well drained, medium textured soils on glacial till plains and level, poorly drained, medium textured and moderately fine textured soils in narrow outwash channels

This association is in narrow outwash channels and adjacent areas. It is mostly nearly level. All areas drain in a northwest-to-southeast direction. Areas of this association are long and narrow. They range from 10 to 30 miles long and 1½ to 2 miles wide.

This association covers about 10 percent of the county. Barnes soils make up about 70 percent of the association, Colvin soils 10 percent, and minor soils 20 percent.

Barnes soils are on both sides of the drainage channels. They are deep, nearly level, and well drained. The surface layer is black loam about 7 inches thick. The subsoil is dark grayish-brown and dark-brown loam 9 inches thick. The underlying material is calcareous loam glacial till.

Colvin soils are in the outwash channels. They are deep, level, and poorly drained. The surface layer is black silt loam or silty clay loam about 7 inches thick. The underlying material is silty clay loam that has lime concentrated in the upper part.

The minor soils are Divide, Renshaw, Arvilla, and Marysland soils, which formed in outwash and are underlain by sand and gravel, and Hamerly soils, which formed in glacial till. The Arvilla and Renshaw soils are somewhat excessively drained. The Divide soils are somewhat poorly drained, and the Marysland soils are poorly drained. The Hamerly soils are moderately well drained and calcareous.

Nearly all the acreage of the Barnes soils in this association is cultivated. These soils are well suited to all crops common to the county, and for these soils, there are few management problems. In most years the Colvin soils are too wet for cultivation. The Colvin and Marysland soils are used for pasture, hay, and wildlife habitat. The Arvilla and Renshaw soils in many places are used for crops, but they are droughty. The Divide and Hamerly soils are mostly used for crops, but in most years tillage is delayed in spring because of wetness.

6. *Arvilla-Renshaw-Colvin association*

Level and nearly level, somewhat excessively drained and poorly drained, moderately coarse textured to moderately fine textured soils on gravel terraces and in outwash channels

This association is in glacial outwash channels and on adjacent gravel terraces. Areas are long and narrow and drain in a northwest-to-southeast direction.

This association covers about 3 percent of the county. Arvilla soils make up about 30 percent of the association, Renshaw soils 20 percent, Colvin soils 5 percent, and minor soils 45 percent.

Arvilla soils are shallow to coarse sand and gravel and are somewhat excessively drained. The surface layer is very dark brown sandy loam about 6 inches thick. The subsoil is dark-brown sandy loam about 9 inches thick. The underlying material is coarse sand and gravel.

Renshaw soils are shallow to coarse sand and gravel and are somewhat excessively drained. The surface layer is black loam about 5 inches thick. The subsoil is very dark grayish-brown loam about 11 inches thick. The underlying material is coarse sand and gravel.

Colvin soils are level, deep, and poorly drained. The surface layer is black silt loam or silty clay loam about 7 inches thick. The underlying material is silty clay loam that has lime concentrated in the upper part.

Some of the minor soils are Sioux, Divide, Lohnes, and Hecla soils. The Sioux soils are underlain by gravel and sand at a depth of about 5 inches. The Divide soils are calcareous, somewhat poorly drained, and underlain by gravel and sand at a depth of about 24 inches. The Hecla and Lohnes soils are moderately well drained loamy sands.

The Arvilla and Renshaw soils in this association are suited to cultivation but are droughty. Soil blowing is a severe hazard on the Arvilla soils. Most areas are in native or tame grass. In most years the Colvin soils are too wet for cultivation. They are used for pasture, hay, and wildlife habitat. The minor soils are also used mostly for tame and native grass. Management is needed mainly in areas used for grass.

7. *Barnes association*

Undulating and nearly level, well drained, medium textured soils on glacial till plains

This association is undulating and nearly level. It covers about 2 percent of the county. Undulating areas of Barnes soils make up about 45 percent of the association and nearly level areas 35 percent. Minor soils make up 20 percent.

Barnes soils are on nearly level to convex side slopes. They are deep and well drained. The surface layer is black loam about 7 inches thick. The subsoil is dark grayish-brown and dark-brown loam 9 inches thick. The underlying material is calcareous loam glacial till.

The minor soils in this association are Hamlet, Hamerly, Tonka, and Parnell soils. The Hamlet soil is moderately well drained and is in swales and slightly concave areas. The Hamerly soil is nearly level, calcareous, and on rims around depressions. The Tonka soils are poorly drained, and Parnell soils are very poorly drained; both are in depressions.

The growing of cash crops is the main enterprise. The soils of this association have a high potential for all cultivated crops commonly grown in the county. Nearly all the acreage is used for cultivated crops. Fertility and available water capacity are high. Concerns of management are controlling erosion and improving drainage in the depressions.

Descriptions of the Soils

This section describes the soil series and mapping units in Renville County. Each soil series is described in detail and then, briefly, each mapping unit in that series. Unless specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile; that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. The profile described in the series is representative of mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit. Color terms are for moist soils unless otherwise stated.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Gravel pits and Marsh, for example, do not belong to a soil series but, nevertheless, are listed in alphabetic order along with the soil series.

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit are the capability unit and windbreak suitability group in which the mapping unit has been placed. The page for the description of each capability unit and windbreak suitability group can be learned by referring to the "Guide to Mapping Units" at the back of this survey.

The approximate acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*4*).[1]

Arveson Series

The Arveson series consists of deep, poorly drained, level soils. They have an accumulation of lime within a depth of 16 inches.

In a representative profile the surface layer is black loam about 9 inches thick. The underlying material, to a depth of about 14 inches, is dark-gray, very friable loam that has an accumulation of lime. Below this, it is very

[1] Italic numbers in parentheses refer to Literature Cited, p. 75.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Arveson loam	656	0.1	Hamlet-Tonka loams, 1 to 3 percent slopes	13,404	2.3
Arvilla sandy loam, 6 to 9 percent slopes	211	(1)	Hecla and Lohnes loamy sands, 1 to 3 percent slopes	535	.1
Arvilla-Sioux sandy loams, 1 to 3 percent slopes	5,745	1.0	LaDelle silty clay loam, 1 to 3 percent slopes	1,998	.3
Arvilla-Sioux sandy loams, 3 to 6 percent slopes	749	.1	Lohnes loamy sand, 3 to 6 percent slopes	797	.1
Barnes loam, 1 to 3 percent slopes	153,417	26.6	Ludden silty clay	911	.2
Barnes loam, 3 to 6 percent slopes	39,860	6.9	Ludden silty clay, very wet	210	(1)
Barnes loam, 6 to 9 percent slopes	4,003	.7	Marsh	1,549	.3
Barnes loam, 9 to 12 percent slopes	424	.1	Marysland silt loam	1,507	.3
Barnes cobbly loam, 1 to 6 percent slopes	935	.2	Parnell silty clay loam	8,540	1.5
Barnes-Buse loams, 3 to 6 percent slopes	3,235	.6	Renshaw loam, 1 to 3 percent slopes	3,122	.5
Barnes-Buse loams, 6 to 9 percent slopes	2,398	.4	Renshaw loam, 3 to 6 percent slopes	325	.1
Barnes-Cresbard loams, 1 to 3 percent slopes	1,711	.3	Sioux loam, 1 to 6 percent slopes	2,362	.4
Barnes-Hamerly loams, 3 to 6 percent slopes	3,195	.6	Sioux loam, 6 to 20 percent slopes	1,367	.2
Barnes-Hamlet-Tonka loams, 1 to 3 percent slopes	162,249	28.1	Svea loam, 1 to 3 percent slopes	4,826	.8
Barnes-Hamlet-Tonka loams, 3 to 6 percent slopes	27,462	4.8	Svea loam, 3 to 6 percent slopes	549	.1
Barnes and Buse very stony loams, 3 to 15 percent slopes	361	.1	Svea loam, channeled, 1 to 6 percent slopes	1,484	.3
Cavour-Cresbard loams, 1 to 3 percent slopes	319	.1	Svea loam, fans, 1 to 3 percent slopes	597	.1
Colvin silt loam	1,428	.2	Svea loam, fans, 3 to 6 percent slopes	652	.1
Colvin soils, channeled	4,528	.8	Swenoda fine sandy loam, 1 to 3 percent slopes	10,474	1.8
Colvin soils, very wet	848	.2	Swenoda fine sandy loam, 3 to 6 percent slopes	2,580	.5
Divide loam, loamy substratum, 1 to 3 percent slopes	3,481	.6	Tiffany fine sandy loam	243	(1)
Embden sandy loam, 1 to 6 percent slopes	1,930	.3	Tonka silt loam	15,282	2.7
Embden-Tiffany fine sandy loams, 1 to 3 percent slopes	235	(1)	Vallers loam	1,456	.3
Fargo silty clay	2,718	.5	Velva loam	2,377	.4
Fargo silty clay, very wet	254	(1)	Velva loam, channeled	571	.1
Fulda silty clay loam	3,077	.5	Williams loam, 1 to 3 percent slopes	418	.1
Gravel pits	834	.1	Williams loam, 3 to 6 percent slopes	460	.1
Great Bend silty clay loam, 1 to 3 percent slopes	3,366	.6	Wyndmere fine sandy loam, 1 to 3 percent slopes	269	(1)
Hamerly loam, 1 to 3 percent slopes	4,842	.8	Zahl-Max loams, 9 to 15 percent slopes	6,339	1.1
Hamerly-Tonka loams, 1 to 3 percent slopes	15,348	2.7	Zahl-Max loams, 15 to 60 percent slopes	15,905	2.8
Hamlet-Hamerly-Tonka loams, 1 to 3 percent slopes	16,100	2.8	Ponds	204	(1)
			Lake Darling and Souris River	9,269	1.6
			Total	576,501	100.0

[1] Less than 0.05 percent.

dark gray, gray, and olive-gray sandy loam over grayish-brown sand and yellowish-brown sand.

Permeability is moderately rapid, and the available water capacity is moderate. Runoff is very slow. The content of organic matter is moderate, and fertility is medium. The water table is within a depth of 1 to 3 feet for extended periods during the growing season. These soils are occasionally subject to ponding.

Most areas are in grass and used for hay and pasture. These soils are suited to crops if excess water is removed.

Representative profile of Arveson loam, 1,750 feet north and 1,050 feet west of the southeast corner of sec. 15, T. 163 N., R. 84 W., in native grass.

A1—0 to 9 inches, black (10YR 2/1) loam, dark gray and gray (10YR 4/1 and 5/1) when dry; weak, medium, subangular blocky structure parting to weak, medium, crumb; slightly hard, very friable, nonsticky and slightly plastic; strong effervescence; mildy alkaline; clear, wavy boundary.

C1ca—9 to 14 inches, dark-gray (10YR 4/1) loam, light gray (10YR 6/1) when dry; weak, medium, subangular blockly structure; slightly hard, very friable, nonsticky and nonplastic; violent effervescence; moderately alkaline; clear, wavy boundary.

C2—14 to 18 inches, very dark gray (10YR 3/1) sandy loam, gray (10YR 5/1) when dry; weak, medium, subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; slight effervescence; mildly alkaline; clear, wavy boundary.

C3g—18 to 23 inches, gray and olive-gray (5Y 5/1 and 5/2) sandy loam, light gray (5Y 6/1) when dry; single grained; soft, very friable, nonsticky and nonplastic; slight effervescence; mildly alkaline; gradual, wavy boundary.

IIC4g—23 to 27 inches, grayish-brown (2.5Y 5/2) sand, light brownish gray (2.5Y 6/2) when dry; some yellowish-brown (10YR 5/6) sand grains; single grained; loose, nonsticky and nonplastic; slight effervescence; mildly alkaline; gradual, wavy boundary.

IIC5g—27 to 33 inches, yellowish-brown (10YR 5/6) sand, yellowish brown (10YR 5/6) when dry; single grained; loose, nonsticky and nonplastic; slight effervescence; mildly alkaline; gradual, wavy boundary.

IIC6g—33 to 63 inches, grayish-brown (2.5Y 5/2) sand, light brownish gray (2.5Y 6/2) when dry; some yellowish-brown (10YR 5/6) sand grains; single grained; loose, nonsticky and nonplastic; slight effervescence; mildly alkaline.

The A horizon is black or very dark gray, and 6 to 15 inches thick. It is loam in most places but it is very fine sandy loam in some places. The C1ca horizon is loam or fine sandy loam, but below this, the underlying material is sandy loam, loamy sand, or sand.

Arveson soils formed in the same kind of material as Hecla and Wyndmere soils, but they are more poorly drained than those soils. They contain more lime in the upper part of the C horizon than Hecla soils.

Ar—Arveson loam. This soil is level and is in small, slight depressions of glacial outwash. The slope is 0 to 1 percent. Included with this soil in mapping were some areas of soils that have a surface layer of fine sandy loam.

This soil is moderately susceptible to soil blowing in cultivated areas. The water table is very high during the growing season in most years. The soil is ponded for short periods in some years.

Most of the acreage is in grass and used for hay and pasture. The soil is suited to cultivated crops if excess water is removed, but few areas have adequate drainage outlets. Wetness is the main concern of management. Capability unit IIIw–5; windbreak suitability group 2.

Arvilla Series

The Arvilla series consists of somewhat excessively drained, nearly level to gently rolling soils that are shallow to coarse sand and gravel. These soils formed in moderately coarse textured glacial outwash underlain by sand and gravel.

In a representative profile the surface layer is very dark brown sandy loam about 6 inches thick. The subsoil is dark-brown, very friable sandy loam about 9 inches thick. The underlying material is very dark grayish-brown gravelly loamy sand in the upper part and brown gravel and sand in the lower part.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the underlying sand and gravel. The available water capacity is low. Runoff is slow. The content of organic matter is moderately low, and fertility is low.

Most areas are cultivated and used for small grain and tame pasture. These droughty soils have low productivity.

Representative profile of Arvilla sandy loam, in an area of Arvilla-Sioux sandy loams, 1 to 3 percent slopes, 1,434 feet south and 126 feet east of the northwest corner of sec. 26, T. 160 N., R. 84 W., in a cultivated field.

Ap—0 to 6 inches, very dark brown (10YR 2/2) sandy loam, very dark gray (10YR 3/1) when dry; weak, medium, granular structure parting to single grained; soft, loose, nonsticky and nonplastic; neutral; abrupt, smooth boundary.

B2—6 to 15 inches, dark-brown (10YR 3/3) sandy loam, grayish brown (10YR 5/2) when dry; weak, coarse, prismatic structure parting to weak, medium and fine, subangular blocky; slightly hard, very friable, nonsticky and nonplastic; neutral; clear, wavy boundary.

IIC1—15 to 22 inches, very dark grayish-brown (10YR 3/2) gravelly loamy sand, dark grayish brown (10YR 4/2) when dry; single grained; loose, nonsticky and nonplastic; slight effervescence; mildly alkaline: gradual, wavy boundary.

IIC2—22 to 60 inches, brown (10YR 5/3) gravel and sand, pale brown (10YR 6/3) when dry; single grained; loose, nonsticky and nonplastic; slight effervescent; mildly alkaline.

The A and B horizons range from 10 to 20 inches in combined thickness. The A1 horizon is generally black, but it is very dark brown in cultivated areas where it has been mixed with the upper part of the B horizon. The gravel and sand have slight to strong effervescence, and the underside of pebbles is coated with lime. The IIC horizon ranges from 10 to 25 percent gravel.

Arvilla soils formed in the same kind of material as Renshaw and Sioux soils, but they have more sand in the solum than Renshaw soils and are deeper to coarse sand and gravel than Sioux soils.

AvC—Arvilla sandy loam, 6 to 9 percent slopes. This soil is gently rolling and is in areas of sandy outwash. It has a profile similar to the one described as representative of the series, but the underlying material is medium and coarse sand instead of coarse sand and gravel.

This soil is droughty and is highly susceptible to soil blowing. Runoff is slow.

Most of the acreage is used for tame grass and alfalfa. The soil is not well suited to cultivated crops. It is better suited to hay and pasture than to other uses. Low fertility, droughtiness, and soil blowing are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

AwA—Arvilla-Sioux sandy loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are in areas of gravelly outwash. About 80 percent of the complex is Arvilla sandy loam, and 20 percent is Sioux sandy loam. The Arvilla soil has concave and plane slopes, and the Sioux soil has convex areas. The Sioux soil is shallower to sand and gravel than the Arvilla soil. The Arvilla soil has the profile described as representative of the Arvilla series.

Both soils are droughty and are highly susceptible to soil blowing. Runoff is slow.

This complex is not well suited to cultivated crops. Many areas once used for annual crops are now in grass and used for tame pasture and hay. Droughtiness and soil blowing are the main concerns of management. Capability unit IIIe-3; Arvilla soil in windbreak suitability group 6; Sioux soil in windbreak suitability group 10.

AwB—Arvilla-Sioux sandy loams, 3 to 6 percent slopes. The soils making up this complex are gently sloping and are in areas of gravelly outwash. About 75 percent of the complex is Arvilla sandy loam, and 25 percent is Sioux sandy loam. The Arvilla soil has concave and plane slopes, and the Sioux soil has convex slopes. The Sioux soil is shallower to sand and gravel than the Arvilla soil.

Both soils are droughty and are highly susceptible to soil blowing. Runoff is slow.

This complex is not well suited to cultivated crops. Many areas once used for annual crops are now in grass and used for tame pasture and hay. Droughtiness and soil blowing are the main concerns of management. Capability unit IIIe-3; Arvilla soil in windbreak suitability group 6; Sioux soil in windbreak suitability group 10.

Barnes Series

The Barnes series consists of deep, well-drained, nearly level to rolling soils. These soils have plane and convex slopes and are on glacial till plains. They formed in calcareous, loamy glacial till.

In a representative profile (fig. 2) the surface layer is black loam about 7 inches thick. The subsoil is dark-brown, friable loam about 9 inches thick. The upper part of the underlying material is light olive-brown loam that contains a large amount of lime, and the lower part is mottled olive-brown loam.

Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. The available water capacity is high. Runoff is slow to rapid. The content of organic matter is moderate, and fertility is high.

Barnes soils are well suited to farming. Most areas are used for crops, but some are used for hay and pasture.

Representative profile of Barnes loam, 1 to 3 percent slopes, 2,400 feet east and 75 feet south of the northwest corner of sec. 18, T. 158 N., R. 82 W., in a cultivated field.

Ap—0 to 7 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; cloddy; soft, friable, sticky and plastic; neutral; clear, smooth boundary.

B21t—7 to 12 inches, dark-brown (10YR 4/3) loam, dark grayish brown (10YR 4/2) when dry; moderate, medium, prismatic structure; hard, friable, sticky and plastic; patches of distinct, very dark grayish-brown (10YR 3/2) clay films on faces of peds; neutral; gradual, wavy boundary.

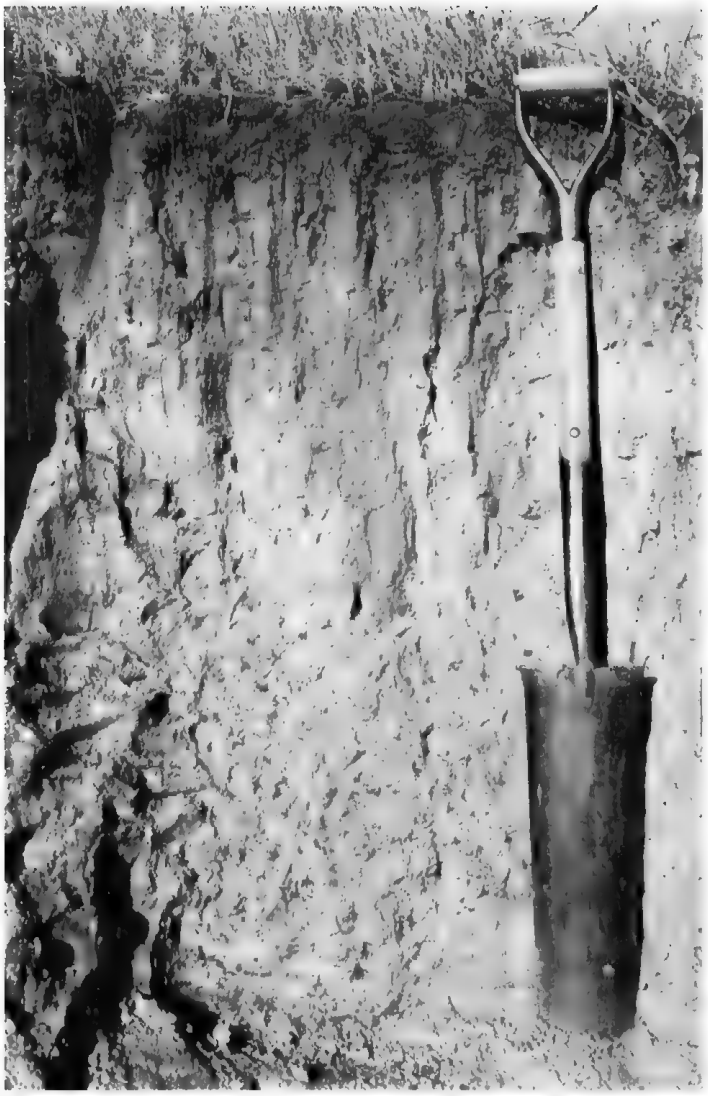

Figure 2.—**Profile of Barnes loam.**

B22—12 to 16 inches, dark-brown (10YR 4/3) loam, brown (10YR 5/3) when dry; weak, medium, prismatic structure; hard, friable, sticky and plastic; patches of clay films on faces of peds; slight effervescence; mildly alkaline; clear, wavy boundary.

C1ca—16 to 36 inches, light olive-brown (2.5Y 5/4) loam, pale yellow (5Y 7/3) when dry; weak, medium, prismatic structure parting to weak, fine, subangular blocky; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; gradual boundary.

C2—36 to 60 inches, olive-brown (2.5Y 4/4) loam, pale yellow (5Y 7/3) when dry; common, fine, distinct, gray (2.5Y 6/1) mottles; massive; hard, firm, sticky and plastic; few small shale fragments; strong effervescence; moderately alkaline.

In many places the Ap horizon is very dark brown because it has been mixed with the upper part of the B2 horizon. It ranges from 4 to 8 inches in thickness. The B horizon is loam or light clay loam 5 to 14 inches thick. Pebbles and cobbles are common throughout the profile.

Barnes soils are associated with Svea, Hamlet, and Buse soils. They are better drained and have a thinner A horizon than Svea and Hamlet soils. They have a thicker solum than Buse soils, and they do not lack a B horizon.

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BaA—Barnes loam, 1 to 3 percent slopes. This soil is nearly level and is on glacial till plains. The landscape is smooth. The soil has the profile described as representative of the series. Included with this soil in mapping and making up 5 to 15 percent of the acreage were areas of Hamlet soils in swales and Tonka soils in depressions.

This Barnes soil is susceptible to soil blowing and water erosion. Runoff is slow.

This soil is well suited to crops, and most of the acreage is cultivated. Soil blowing and water erosion are easily controlled. Climate is the major limitation to use of this soil. Capability unit IIc–6; windbreak suitability group 3.

BaB—Barnes loam, 3 to 6 percent slopes. This soil is undulating and is on glacial till plains. It is on knolls, low ridges, and gently sloping breaks along drainageways. Included with this soil in mapping were areas of Hamlet soils that make up 5 to 15 percent of the acreage.

On this Barnes soil, the hazards of soil blowing and water erosion are slight. Runoff is medium.

This soil is well suited to crops, and most of the acreage is cultivated. Soil blowing and water erosion are easily controlled. Capability unit IIe–6; windbreak suitability group 3.

BaC—Barnes loam, 6 to 9 percent slopes. This soil is gently rolling and has short, irregular slopes. It has a profile similar to the one described as representative of the series, but the surface layer and subsoil average about 3 inches thinner. The surface layer and subsoil are thickest on foot slopes and thinnest on upper, convex slopes. On the convex slopes, the present plow layer has been mixed with part of the subsoil and is browner than the original surface layer, but in a few spots, the soil is eroded enough that the plow layer has been mixed with part of the limy underlying material. These spots are light olive brown, and are conspicuous in summer-fallowed fields.

Runoff is medium, and water erosion is the main hazard in cultivated areas.

This soil is well suited to crops and is used mainly for that purpose. Capability unit IIIe–6; windbreak suitability group 3.

BaD—Barnes loam, 9 to 12 percent slopes. This soil is rolling and is on the upper edges of valleys of the Des Lacs and Souris Rivers. This soil has a profile similar to the one described as representative of the series, but the surface layer and subsoil are 3 to 5 inches thinner. The surface layer and subsoil are thinnest where the soil is most strongly sloping. Included with this soil in mapping, and making up 10 to 15 percent of the acreage, were areas of Buse loam on convex slopes of breaks.

This Barnes soil commonly is moderately eroded in cultivated areas, where the hazard of water erosion is severe. Runoff is rapid.

This soil is better suited to grass than to other uses, and most of the acreage is in native grass. In cultivated areas water erosion is difficult to control. Capability unit IVe–6; windbreak suitability group 10.

BbB—Barnes cobbly loam, 1 to 6 percent slopes. In most places, this soil is undulating, but in some places it is nearly level. It is on low knolls and ridges. It has a surface layer of cobbly loam or gravelly loam (fig. 3). In nearly level areas, the glacial till in which this Barnes soil formed contains many more cobbles and pebbles than is

Figure 3.—Area of Barnes cobbly loam, 1 to 6 percent slopes.

common for material in which other soils of the Barnes series formed. This soil has a profile similar to the one described as representative of the series, except for the cobbles and gravel.

Runoff is medium, and the hazards of soil blowing and water erosion are slight.

Most of the acreage is cultivated. The soil is well suited to crops, but in some areas there are so many cobbles that they interfere with tillage and seeding. Soil blowing and water erosion are easily controlled. Capability unit IIe–6; windbreak suitability group 3.

BdB—Barnes-Buse loams, 3 to 6 percent slopes. The soils making up this complex are undulating and have short, irregular slopes. About 60 percent of each area is Barnes loam, 30 percent is Buse loam, and 10 percent is Hamlet loam. The Barnes soil generally is on the lower and less steep parts of the slopes, and the Buse soil is on the crest of slopes and top of knolls. The Barnes soil has a profile similar to the one described as representative of the Barnes series, but the surface layer and subsoil are thinner. The Buse soil has the profile described as representative of the Buse series. It does not have a subsoil and is shallower to underlying material than the Barnes soil. In summer-fallowed areas, the contrasting colors of the surface layer are evident (fig. 4).

Both soils are susceptible to soil blowing and water erosion. Runoff is medium.

This complex is suited to all crops commonly grown in the county, and nearly all the acreage is cultivated. Soil blowing and water erosion are the main limitations to the use of these soils. Capability unit IVe–4L; Barnes soil in windbreak suitability group 3; Buse soil in windbreak suitability group 8.

BdC—Barnes-Buse loams, 6 to 9 percent slopes. The soils making up this complex are gently rolling and have short, irregular slopes. About 55 percent of each area is Barnes loam, 35 percent is Buse loam, and 10 percent is Hamlet loam. The Barnes soil is on plane side slopes, and the Buse soil is on the crests of slopes and the tops of knolls. The Barnes soil has a profile similar to the one described as representative of the Barnes series, but the surface layer and subsoil are thinner. The Buse soil does not have a subsoil and is shallower to underlying material than the Barnes soil. In summer-fallowed fields, the contrasting colors of the surface layer are evident.

Both soils are susceptible to soil blowing and water erosion. Runoff is medium.

This complex is suited to all crops commonly grown in the county, and most of the acreage is cultivated. In cultivated areas soil blowing and water erosion are the main hazards. Capability unit IVe–4L; Barnes soil in windbreak suitability group 3; Buse soil in windbreak suitability group 8.

BfA—Barnes-Cresbard loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are on glacial till plains. About 70 percent of the complex is Barnes loam, and 30 percent is Cresboard loam. The landscape is uniform and no surface features differentiate the two soils, but in dry years, the height to which crops grow on the Cresbard soil is less. The Cresbard soil has the profile described as representative of the Cresbard series.

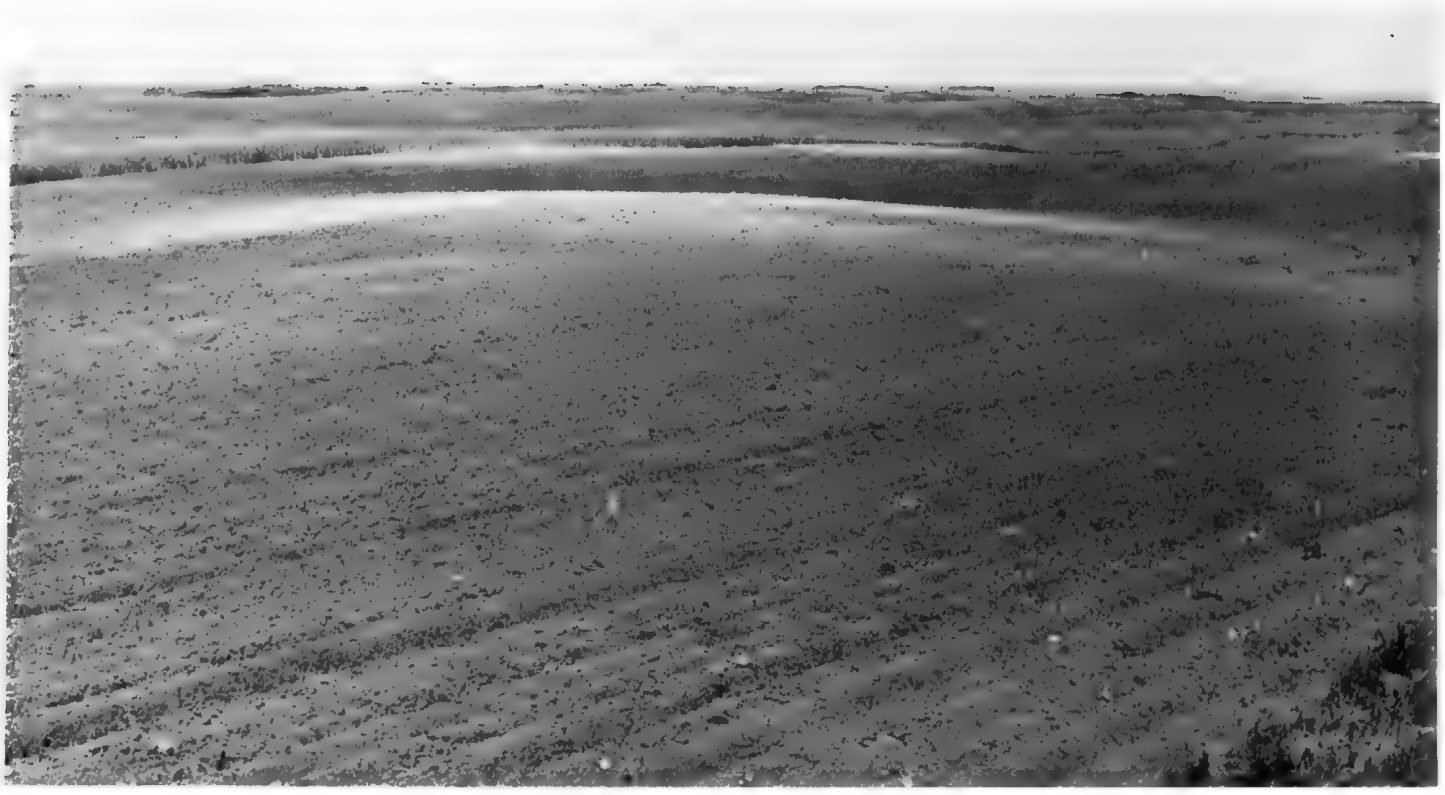


Figure 4.—**Area of Barnes-Buse loams, 3 to 6 percent slopes. The darker colored areas are Barnes soil, and the light-colored areas are Buse soil.**

These soils are susceptible to soil blowing and water erosion. Runoff is medium.

This complex is suited to all crops commonly grown in the county, and most of the acreage is cultivated. The Cresbard soil is more droughty than the Barnes soil because it has a claypan and has soluble salts in the lower part of the subsoil and in the underlying material. Soil blowing and water erosion are easily controlled. Capability unit IIIs–6P; Barnes soil in windbreak suitability group 3; Cresbard soil in windbreak suitability group 4.

BgB—Barnes-Hamerly loams, 3 to 6 percent slopes. The soils making up this complex are undulating and are in irregularly shaped areas around and between depressions of Tonka and Parnell soils on till plains. About 60 percent of the complex is Barnes loam, 30 percent is Hamerly loam, and 10 percent is Tonka and Parnell soils in depressions. The Barnes soil is on the higher side slopes, and the Hamerly soil is on lower side slopes and around the depressions.

Runoff is medium, and the hazards of soil blowing and water erosion are slight.

This complex is suited to most crops. The irregular topography and the depressions limit use of the soils for row crops. Capability unit IIe–6; Barnes soil in windbreak suitability group 3; Hamerly soil in windbreak suitability group 1.

BhA—Barnes-Hamlet-Tonka loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are in large areas of glacial till plains. About 60 percent of the complex is Barnes loam, 20 percent is Hamlet loam, 15 percent is Tonka silt loam, and 5 percent is included areas of Hamerly loam and Parnell silty clay loam. The Barnes soil is in nearly level to slightly convex areas, the Hamlet soil is in slightly concave areas, and the Tonka soil is in depressions (fig. 5). The Hamlet soil has the profile described as representative of the Hamlet series.

These soils are susceptible to soil blowing and to water erosion. Runoff is slow.

This complex is well suited to all crops commonly grown in the county, and nearly all the acreage is cultivated. The Tonka soil is often wet in spring, and consequently tillage and seeding either have to be delayed or cannot be done. Soil blowing and water erosion are easily controlled. Capability unit IIc–6; Barnes soil in windbreak suitability group 3; Hamlet soil in windbreak suitability group 1; Tonka soil in windbreak suitability group 2.

BhB—Barnes-Hamlet-Tonka loams, 3 to 6 percent slopes. The soils making up this complex are undulating and are on glacial till plains. About 60 percent of the complex is Barnes loam, 20 percent is Hamlet loam, 15 percent is Tonka silt loam, and 5 percent is inclusion of Hamerly loam and Parnell silty clay loam. The Barnes soil is in convex areas, the Hamlet soil is in concave areas, and the Tonka soil is in level depressions.

These soils are susceptible to soil blowing and water erosion. Runoff is medium.

This complex is well suited to all crops commonly grown in the county, and nearly all the acreage is culti-

Figure 5.—Area of Barnes-Hamlet-Tonka loams, 1 to 3 percent slopes. Barnes soils are in level and convex areas; Hamlet soils are in concave areas; and Tonka soils are in uncultivated depressions.

vated. The Tonka soil is often wet in spring, and consequently tilling and seeding either have to be delayed or cannot be done. Soil blowing and water erosion are easily controlled. Capability unit IIc–6; Barnes soil in windbreak suitability group 3; Hamlet soil in windbreak suitability group 1; Tonka soil in windbreak suitability group 2.

BnD—Barnes and Buse very stony loams, 3 to 15 percent slopes. The soils making up this undifferentiated unit are undulating to rolling and are in grassy areas of glacial till plains. Some areas consist of Barnes very stony loam, some consist of Buse very stony loam, and some contain both soils. The Barnes soil is generally on plane side slopes, and the Buse soil is generally on convex slopes. These soils are mapped together because they are managed in the same way and are limited in extent.

Runoff is medium to rapid.

These soils have so many stones that cultivation is not possible (fig. 6). They are better suited to grazing than to other uses. Most of the acreage is used for pasture. Both soils are in capability unit VIIs-6 and windbreak suitability group 10.

Buse Series

The Buse series consists of deep, well-drained, undulating to rolling soils. These soils are on till plains. They formed in loamy glacial till.

In a representative profile (fig. 7) the surface layer is very dark grayish-brown loam about 6 inches thick. The upper part of the underlying material is light olive-brown loam that contains an accumulation of lime. The lower part is olive and olive-brown loam.

Permeability is moderate, and the available water capacity is high. Runoff is medium to rapid. The content of organic matter is moderately low, and fertility is medium.

Figure 6.—**Area of Barnes and Buse very stony loams, 3 to 15 percent slopes.**

Figure 7.—**Profile of Buse loam.**

Most areas of these soils are used for crops, but the more sloping areas are better suited to pasture and hay.

Representative profile of Buse loam, in an area of Barnes-Buse loams, 3 to 6 percent slopes, 2,200 feet east and 1,500 feet north of the southwest corner of sec. 10, T. 161 N., R. 86 W., in a cultivated field.

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, grayish brown (10YR 5/2) when dry; weak, medium, subangular blocky structure parting to moderate, medium, crumb; slightly hard, very friable, slightly sticky and slightly plastic; strong effervescence; mildly alkaline; abrupt, smooth boundary.

C1ca—6 to 16 inches, light olive-brown (2.5Y 5/4) loam, light yellowish brown (2.5Y 6/4) when dry; weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

C2—16 to 30 inches, olive (5Y 4/3) loam, pale olive (5Y 6/3) when dry; weak, medium, subangular blocky structure; hard, friable, sticky and plastic; strong effervescence; moderately alkaline; gradual, wavy boundary.

C3—30 to 60 inches, olive-brown (2.5Y 4/4) loam, light olive brown (2.5Y 5/4) when dry; massive; hard, friable, sticky and slighdy plastic; strong effervescence; moderately alkaline.

The A1 horizon is black or very dark gray and ranges from 4 to 7 inches in thickness. In cultivated areas, the A horizon generally has been mixed with the upper part of the C horizon, and consequently the Ap horizon is very dark grayish brown and strongly effervescent.

Buse soils formed in the same kind of material as Barnes and Svea soils, but they lack a B horizon, which is typical of those soils, and they have a thinner solum.

Buse soils in Renville County are mapped only with Barnes soils.

Cavour Series

The Cavour series consists of deep, moderately well drained, nearly level soils that have a claypan. These soils formed in clay loam glacial till.

In a representative profile the surface layer is very dark gray loam about 6 inches thick. The subsoil is clay, about 8 inches thick, that is very dark gray and extremely firm in the upper part and very dark grayish brown and very firm in the lower part. The underlying material is mottled clay loam. The upper part is very dark grayish brown and olive brown and contains a large amount of gypsum. The lower part is dark grayish brown and contains some lime and gypsum.

Permeability is very slow, and the available water capacity is moderate. Runoff is slow. The content of organic matter is moderate, and fertility is medium. The claypan restricts the growth of roots and the permeability.

Most areas are cultivated, but some are used for hay and pasture.

Representative profile of Cavour loam, in an area of Cavour-Cresbard loams, 1 to 3 percent slopes, 1,420 feet east and 220 feet south of the northwest corner of sec. 18, T. 163 N., R. 86 W., in a cultivated field.

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) when dry; moderate, medium, platy structure; slightly hard, very friable, slightly sticky and slightly plastic; mildly alkaline; abrupt, smooth boundary.

B21t—6 to 9 inches, very dark gray (10YR 3/1) clay, gray (10YR 5/1) when dry; column tops are light gray (10YR 6/1 and 7/1) when dry; strong, medium, columnar structure parting to strong, medium and fine, angular blocky; extremely hard, extremely firm, very sticky and very plastic; continuous black (10YR 2/1) clay films on all faces; strongly alkaline; clear, wavy boundary.

B22t—9 to 14 inches, very dark grayish-brown (10YR 3/2) clay, very dark grayish brown (10YR 3/2) when dry; strong, medium, prismatic structure parting to strong, medium and fine, angular blocky; very hard, very firm, very sticky and very plastic; continuous very dark brown (10YR 2/2) clay films on all faces; strongly alkaline; clear, wavy boundary.

C1cs—14 to 23 inches, olive-brown and very dark grayish-brown (2.5Y 4/4 and 3/2) clay loam, very dark grayish brown (2.5Y 3/2) when dry; common, medium, distinct, gray (N 5/0) mottles; weak subangular blocky structure; hard, firm, sticky and plastic; many, large nests of gypsum that are light yellowish-brown (2.5Y 6/4) when dry; strongly alkaline; gradual, irregular boundary.

C2—23 to 36 inches, dark grayish-brown (2.5Y 4/2) clay loam, light brownish gray (2.5Y 6/2) when dry; many, fine, prominent, light-gray (N 6/0) mottles; massive; hard, firm, sticky and plastic; strong effervescence; strongly alkaline; gradual, irregular boundary.

C3—36 to 60 inches, dark grayish-brown (2.5Y 4/2) clay loam, light olive brown (2.5Y 5/4) when dry; many, fine, prominent, light-gray (N 6/0) mottles; massive; hard, firm, sticky and plastic; common nests of gypsum; strong effervescence; moderately alkaline.

The Ap horizon is very dark gray or black. Clear bleached sand grains are common. In places an A2 horizon has been mixed with the Ap horizon through cultivation. The B horizon is clay or clay loam.

Cavour soils are associated with Cresbard soil. They have a more firm and dense B horizon than Cresbard soils.

CaA—Cavour-Cresbard loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are on glacial till plains. About 60 percent of the complex is Cavour loam, and 40 percent is Cresbard loam. The Cavour soil has the profile described as representative of the Cavour series. It has a firmer claypan than the Cresbard soil.

These soils are susceptible to soil blowing and water erosion. Runoff is slow.

Most areas of this complex are cultivated, but the soils are not well suited to cultivated crops. The claypan restricts the growth of roots and permeability. Soil blowing and water erosion are easily controlled. The claypan is the main concern of management. Capability unit IVs–6P; Cavour soil in windbreak suitability group 9; Cresbard soil in windbreak suitability group 4.

Colvin Series

The Colvin series consists of deep, poorly drained, level soils that have a zone of lime within 16 inches of the surface. These soils are in shallow depressions and swales in areas of glacial outwash.

In a representative profile the surface layer is black silt loam about 7 inches thick. The underlying material is silty clay loam that contains a large amount of lime. The upper part is dark gray, and the lower part is light brownish gray.

Permeability is moderately slow, and the available water capacity is high. Runoff is very slow. The content of organic matter and fertility are high. The water table is generally within 1 foot to 3 feet of the surface early in spring and during periods of heavy rainfall.

Most areas are in native grass and used for hay and pasture. These soils are suited to cultivation if excess water is removed.

Representative profile of Colvin silt loam, in an area of Colvin soils, channeled, 600 feet east and 45 feet north of the southwest corner of sec. 12, T. 161 N., R. 85 W., in a native pasture.

A1—0 to 7 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak, fine, crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; slight effervescence; mildly alkaline; abrupt, wavy boundary.

C1gca—7 to 14 inches, dark-gray (N 4/0) silty clay loam, gray and light gray (N 5/0 and 7/0) when dry; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, very friable, sticky and plastic; strong effervescence; moderately alkaline; clear, wavy boundary.

C2gca—14 to 30 inches, dark-gray (N 4/0) silty clay loam, gray and light gray (N 5/0 and 7/0) when dry; weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; clear, wavy boundary.

C3gca—30 to 42 inches, dark-gray (N 4/0) silty clay loam, gray and light gray (N 5/0 and 7/0) when dry; massive; hard, friable, sticky and plastic; few pebbles at a depth of 42 inches; violent effervescence; moderately alkaline; gradual, wavy boundary.

C4gca—42 to 48 inches, light brownish-gray (2.5Y 6/2) silty clay loam, light gray (2.5Y 7/2) when dry; few, fine, prominent, yellowish-brown (10YR 5/6) mottles and common, medium, prominent, grayish-brown (2.5Y 5/2) mottles; massive; hard, friable, sticky and plastic; violent effervescence; lime is diffused throughout; moderately alkaline; gradual, wavy boundary.

C5gca—48 to 60 inches, light brownish-gray (2.5Y 6/2) silty clay loam, light gray (2.5Y 7/2) when moist; common, medium, distinct, light olive-brown (2.5Y 5/4) mottles and common, medium, prominent, yellowish-brown (10YR 5/6) mottles; massive; hard, firm, sticky and plastic; violent effervescence; moderately alkaline.

The A horizon is black or very dark gray and ranges from 6 to 14 inches in thickness. The A and C horizons are silt loam or silty clay loam. In places the C1ca horizon contains tongues of material from the A1 horizon.

Colvin soils occur in places that are similar to those areas where Vallers, Marysland, and Divide soils occur, but they are finer textured and contain more silt than Vallers soils, and they do not have sandy and gravelly underlying material, which Marysland and Divide soils have.

Co—Colvin silt loam. This soil is level and is on outwash plains and in shallow lake basins. The slope is 0 to 1 percent. Included with this soil in mapping were small areas of Vallers loam.

Runoff is very slow. The water table is near the surface in spring and during prolonged wet periods. This soil is ponded for a few days in some years, and tillage is delayed by wetness in most years. The hazard of soil blowing is severe in cultivated areas.

This soil is well suited to grass used for hay or pasture. It is suited to cultivated crops if excess water is removed, and most of the acreage is cultivated. Wetness and soil blowing are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Cp—Colvin soils, channeled. These soils are level and are on outwash plains dissected by drainageways (fig. 8). The slope is 0 to 1 percent. The Colvin silt loam in this mapping unit has the profile described as representative of the series. The surface layer is silt loam or silty clay loam.

Runoff is very slow. The water table is near the surface in spring and during prolonged wet periods. These soils are ponded in places for extended periods in some years. The hazard of soil blowing is severe in cultivated areas.

Most of the acreage is used for native pasture and hay. The soils are wet and too cut up by drainage channels to be suited to cultivated crops. Tillage is delayed by wetness in most years. Capability unit Vw–4; windbreak suitability group 10.

Cr—Colvin soils, very wet. These soils are level and are in shallow depressions on outwash plains. The slope is 0 to 1 percent. These soils have a profile similar to the one described as representative of the series, but the surface layer of silt loam or silty clay loam is thicker and, in some places, covered by a thin layer of muck.

Figure 8.—**The dark-colored meander, in center, is a drainage channel through an area of Colvin soils, channeled.**

Runoff is very slow. These soils are ponded until midsummer or throughout the entire season in most years.

Nearly all the acreage is in native grass. These soils are used mainly for late-season hay. They are too wet for cultivated crops. Capability unit Vw–4; windbreak suitability group 10.

Cresbard Series

The Cresbard series consists of deep, moderately well drained, nearly level soils that have a claypan. These soils are in plane and concave areas on the till plain. They formed in loam glacial till.

In a representative profile the surface layer is very dark gray loam about 6 inches thick. The upper part of the subsoil, about 10 inches thick, is very dark grayish-brown, firm clay loam. The lower part, about 4 inches thick, is olive-brown, firm clay loam that contains gypsum salts. The upper part of the underlying material is olive-brown clay loam that contains crystals of gypsum and an accumulation of lime. The lower part is olive-brown loam.

Permeability is moderately slow, and the available water capacity is high. Runoff is slow. The content of organic matter is moderate, and fertility is high.

Cresbard soils are suited to farming. Most areas are used for crops.

Representative profile of Cresbard loam, in an area of Barnes-Cresbard loams, 1 to 3 percent slopes, 1,150 feet east and 50 feet south of the northwest corner of sec. 30, T. 159 N., R. 86 W., in a cultivated field.

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) when dry; weak, medium, subangular blocky structure parting to moderate, fine, crumb; slightly hard, friable, sticky and plastic; neutral; abrupt, smooth boundary.

B2t—6 to 16 inches, very dark grayish-brown (10YR 3/2) clay loam, grayish brown (2.5Y 5/2) when dry; faces of peds are coated with very dark gray (10YR 3/1), dark gray (10YR 4/1) when dry; moderate, medium, prismatic structure parting to strong, medium, angular blocky; hard, firm, very sticky and very plastic; mildly alkaline; clear, wavy boundary.

B3cs—16 to 20 inches, olive-brown (2.5Y 4/4) clay loam, light olive brown (2.5Y 5/4) when dry; weak, medium, subangular blocky structure; hard, firm, sticky and plastic; many, fine, prominent, white gypsum crystals; slight effervescence; moderately alkaline; gradual boundary.

Ccacs—20 to 30 inches, olive-brown (2.5Y 4/4) clay loam, light yellowish brown (2.5Y 6/4) when dry; massive; hard, firm, sticky and plastic; many, fine, prominent, white crystals of gypsum; violent effervescence; strongly alkaline; gradual boundary.

C2ca—30 to 40 inches, olive-brown (2.5Y 4/4) loam, light yellowish brown (2.5Y 6/4) when dry; many, fine, distinct, white (2.5Y 8/2) masses of lime; massive; hard, firm, sticky and plastic; violent effervescence; strongly alkaline; gradual boundary.

C3—40 to 60 inches, olive-brown (2.5Y 4/4) loam, light yellowish brown (2.5Y 6/4) when dry; many, fine, distinct, white (2.5Y 8/2) masses of lime; massive; hard, firm, sticky and plastic; strong effervescence; strongly alkaline.

The solum ranges from 20 to 30 inches in thickness. The A1 horizon is 5 to 8 inches thick. In most places material from the A2 horizon has been mixed with the Ap horizon by cultivation.

Cresbard soils are associated with Barnes, Svea, and Cavour soils. They have a more firm and dense B horizon than Barnes and Svea soils, and their B horizon contains soluble salts. Cresbard soils have a less dense, more friable B horizon than Cavour soils.

Cresbard soils in Renville County are mapped only with Barnes and Cavour soils.

Divide Series

The Divide series consists of somewhat poorly drained, nearly level soils that have a zone of lime within 16 inches of the surface. These soils are in plane and slightly convex areas on glacial outwash plains. They formed in glacial outwash that is moderately deep to sand and gravel.

In a representative profile the surface layer is loam about 8 inches thick. It is black in the upper part and very dark brown in the lower part. The underlying material, to a depth of about 40 inches, contains a large amount of lime. It is dark grayish-brown gravelly loam in the upper part, olive-gray gravelly sandy loam in the middle part, and dark-brown sand and gravel in the lower part. Below this, to a depth of 60 inches, the underlying material is gray and olive-brown loam mottled with dark gray.

Permeability is moderate in the surface layer and the upper part of the underlying material, very rapid in the lower part of the underlying material above a depth of 40 inches, and moderately slow below. The available water capacity is low or moderate. Runoff is slow. The content of organic matter is moderate, and fertility is medium. The water table is within 2 to 5 feet of the surface early in spring and during periods of heavy rainfall.

Divide soils are suitable for farming. They are used for crops, pasture, and hay.

Representative profile of Divide loam, loamy substratum, 1 to 3 percent slopes, 910 feet west and 200 feet north of the southeast corner of sec. 8, T. 162 N., R. 84 W., in a cultivated field.

Ap—0 to 6 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry; moderate, fine, crumb structure; friable, slightly sticky and slightly plastic; slight effervescence; mildly alkaline; clear, smooth boundary.

A12—6 to 8 inches, very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) when dry; moderate, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; slight effervescence; mildly alkaline; clear, wavy boundary.

C1ca—8 to 15 inches, dark grayish-brown (2.5Y 4/2) gravelly loam, light brownish gray and white (2.5Y 6/2 and 8/2) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIC2ca—15 to 24 inches, olive-gray (5Y 5/2) gravelly sandy loam, light gray and white (2.5Y 7/2 and 8/2) when dry; weak, medium, subangular blocky structure parting to single grained; friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; clear, wavy boundary.

IIC3—24 to 40 inches, dark-brown (10YR 4/3) gravel and sand, brown (10YR 5/3) when dry; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline; clear, wavy boundary.

IIIC5g—40 to 48 inches, gray and olive-brown (5Y 5/1 and 2.5Y 4/4) loam, light gray and pale olive (5Y 6/1 and 6/4) when dry; massive; friable, sticky and plastic; strong effervescence; moderately alkaline; gradual, irregular boundary.

IIIC6g—48 to 60 inches, olive-brown (2.5Y 4/4) loam, light olive gray (5Y 6/2) when dry; many, small, prominent dark-gray (5Y 4/1) mottles; massive; firm, sticky and plastic; strong effervescence; moderately alkaline

The A horizon is black or very dark brown and ranges from 5 to 10 inches in thickness. Depth to gravel and sand is 20 to 36 inches. The gravel and sand substratum contains 25 to 50 percent gravel. In this county loam glacial till is within 60 inches of the surface in most places.

Divide soils are in places that are similar to those areas where Marysland soils occur, but they are better drained. They formed in the same kind of material as that in which Renshaw soils formed, but they are more poorly drained.

DdA—Divide loam, loamy substratum, 1 to 3 percent slopes. This soil is nearly level and is in plane and slightly convex areas on glacial outwash plains.

Runoff is slow. This soil has a high water table in spring nearly every year, but only for a short period. The water table is as high during other extremely wet periods as it is in spring. The soil is susceptible to soil blowing in cultivated areas.

Most of the acreage is cultivated. Spring seeding is delayed. The soil is well suited to fall-seeded rye and grass that is used for pasture and hay. Wetness and soil blowing are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 1.

Embden Series

The Embden series consists of deep, moderately well drained, nearly level and undulating soils. These soils are in smooth and slightly concave areas on outwash plains. They formed in moderately coarse textured sediment.

In a representative profile the surface layer is fine sandy loam about 16 inches thick. It is black in the upper part and very dark grayish brown in the lower part. The subsoil is dark grayish-brown very friable fine sandy loam about 8 inches thick. The underlying material is yellowish-brown loamy fine sand in the upper part and mottled grayish-brown sandy loam in the lower part.

Permeability is moderately rapid, and the available water capacity is moderate. Runoff is slow. The content of organic matter is high, and fertility is medium.

Embden soils are well suited to farming. Most areas are used for cultivated crops. Some are used for pasture and hay.

Representative profile of Embden fine sandy loam, in an area of Embden-Tiffany fine sandy loams, 1 to 3 percent slopes, 1,750 feet north and 140 feet east of the southwest corner of sec. 10, T. 158 N., R. 84 W., in a cultivated field.

Ap—0 to 7 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak, fine, crumb structure; slightly hard and very friable; nonsticky and nonplastic; neutral; abrupt, smooth boundary.

A12—7 to 16 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, dark grayish brown (10YR 4/2) when dry; weak, coarse, subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; neutral; clear, wavy boundary.

B2—16 to 24 inches, dark grayish-brown (10YR 4/2) sandy loam, grayish brown (10YR 5/2) when dry; weak, coarse, subangular blocky structure parting to single grained; slightly hard, very friable, nonsticky and nonplastic; neutral; gradual boundary.

C1—24 to 48 inches, yellowish-brown (10YR 5/6) loamy fine sand, yellowish brown (10YR 5/6) when dry; single grained; loose, soft, nonsticky and nonplastic; neutral; gradual boundary.

C2—48 to 60 inches, grayish-brown (10YR 5/2) sandy loam, light gray (10YR 7/2) when dry; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; massive; slightly hard, very friable, nonsticky and nonplastic; strong effervescence; moderately alkaline.

The A horizon is black, very dark gray, or very dark grayish-brown fine sandy loam or sandy loam 10 to 20 inches thick. The B horizon is very dark grayish-brown or dark grayish-brown sandy loam or fine sandy loam 8 to 16 inches thick. In the upper part, the C horizon is fine sandy loam or loamy fine sand, and below a depth of about 40 inches, it is loamy fine sand, loamy sand, or sandy loam. In places there is a Cca horizon.

Embden soils formed in places that are similar to those where Swenoda soils formed, but they do not have the loam substratum that is typical of Swenoda soils. They formed in the same kind of material as Tiffany soils, but they are better drained.

EmB—Embden sandy loam, 1 to 6 percent slopes. This soil is nearly level to undulating and is on outwash plains. It has a profile similar to the one described as representative of the series, but the surface layer is sandy loam. Included with this soil in mapping were small areas of Swenoda fine sandy loam.

This Embden soil is highly susceptible to soil blowing, and it is somewhat droughty. Runoff is slow.

Most of the acreage is used for crops. The soil is well suited to fairly well suited to all crops commonly grown in the county. Soil blowing and the moderate available water capacity are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 1.

EoA—Embden-Tiffany fine sandy loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are on outwash plains. About 80 percent of the complex is Embden fine sandy loam, and 20 percent is Tiffany fine sandy loam. The Embden soil is in smooth and slightly concave areas around slight depressions, and the Tiffany soil is in the depressions. The Embden soil has the profile described as representative of the Embden series.

The Embden soil is better drained than the Tiffany soil. Both soils are highly susceptible to soil blowing. Runoff is slow.

Most areas of this complex are used for crops. The soils are suited to all crops commonly grown in the county. Soil blowing and the moderate available water capacity are the main concerns of management. The Tiffany soil is occasionally ponded for short periods, and tillage is sometimes delayed by wetness. Capability unit IIIe–3; Embden soil in windbreak suitability group 1; Tiffany soil in windbreak suitability group 2.

Fargo Series

The Fargo series consists of deep, poorly drained, level soils. These soils are in glacial lake basins. They formed in calcareous, clayey lacustrine sediment.

In a representative profile the surface layer is black silty clay about 8 inches thick. The subsoil is very firm silty clay about 22 inches thick. It is very dark gray in the upper 7 inches and dark gray below. The underlying material is mottled gray and light-gray silty clay that has gypsum in the lower part.

Permeability is slow, and the available water capacity is high. Runoff is very slow. The content of organic matter and fertility are high.

Most areas are cultivated, but some are used for hay and pasture. These soils are suited to cultivated crops if excess water is removed.

Representative profile of Fargo silty clay, 2,615 feet west and 75 feet south of the northeast corner of sec. 32, T. 161 N., R. 86 W., in a cultivated field.

Ap—0 to 5 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate, medium, angular blocky structure; very hard, very firm, very sticky and very plastic; neutral; abrupt, smooth boundary.

A12—5 to 8 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate, medium, angular blocky structure; very hard, very firm, very sticky and very plastic; neutral; clear, wavy boundary.

B2—8 to 15 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; moderate, fine, angular blocky structure; very hard, very firm, very sticky and very plastic; mildly alkaline; gradual, irregular boundary.

B3g—15 to 30 inches, dark-gray (5Y 4/1) silty clay, gray (5Y 5/1) when dry; moderate, fine, angular blocky structure; very hard, very firm, very sticky and very plastic; strong effervescence; moderately alkaline; gradual boundary.

C1g—30 to 48 inches, gray (5Y 5/1) silty clay, gray (5Y 6/1) when dry; few, fine, faint, olive-brown (2.5Y 4/4) mottles; massive; very hard, very firm, very sticky and very plastic; strong effervescence; few masses of lime; moderately alkaline; gradual boundary.

C2gca—48 to 60 inches, light-gray and gray (5Y 6/1 and 5/1) silty clay, light gray (5Y 6/1) when dry; few, fine, faint, olive-brown (2.5Y 4/4) mottles; massive; very hard, very firm, very sticky and very plastic; strong effervescence; common masses of lime; few nests of gypsum; moderately alkaline.

The solum is 16 to 36 inches thick. The A1 horizon is very dark gray or dark gray when dry and is 6 to 16 inches thick. It is calcareous in the lower part in places where it is thick. The B2 horizon is very dark gray or dark gray when dry and black or very dark gray when moist. It is silty clay or clay and is noncalcareous in places. It has moderate or strong, fine to medium, angular blocky structure. Tongues of A1 material fill cracks and extend through the B2 horizon in places. The Cg horizon ranges from slightly effervescent to strongly effervescent.

Fargo soils are in places similar to areas where Great Bend soils occur, but they are poorly drained and are finer textured than Great Bend soils.

Fa—Fargo silty clay. This soil is level and is in lake basins on glacial till plains. Most of the basins are large. The slope is 0 to 1 percent. The soil has the profile described as representative of the series.

Runoff is very slow. This soil is ponded for a few days after heavy rains, and in some years it is extensively flooded as a result of melting snow. The hazard of soil blowing is severe in spring in unprotected areas.

Most areas are used for cultivated crops. Spring seeding has to be delayed if the soil is wet. The soil is suited to crops and grasses used for hay and pasture. This soil has poor tilth if it is too dry or too wet. Controlling wetness and soil blowing and improving tilth are the main concerns of management. Capability unit IIw–4; windbreak suitability group 1.

Fb—Fargo silty clay, very wet. This soil is level and is in the lowest part of lake basins on glacial till plains. The slope is 0 to 1 percent. It has a profile similar to the one described as representative of the series, but it is wetter.

In most years this soil is ponded or is too wet to cultivate.

This soil is used mainly for pasture and hay and it is best suited to grasses grown for hay or pasture. Suitable outlets for removing excess water are lacking. Capability unit Vw–4; windbreak suitability group 10.

Fulda Series

The Fulda series consists of deep, poorly drained, level soils. These soils are in slightly concave, shallow depressions on glacial till plains. They formed in clayey sediment.

In a representative profile the surface layer is black silty clay loam about 5 inches thick. The upper part of the firm subsoil, about 10 inches thick, is mottled very dark grayish-brown silty clay. The lower part, about 14 inches thick, is grayish-brown and light olive-brown silty clay. The underlying material is mottled grayish-brown and light olive-brown firm clay loam.

Permeability is slow, and the available water capacity is high. Runoff is very slow. The content of organic matter and fertility are high.

Fulda soils are well suited to cultivated crops if excess water is removed. Most areas are cultivated. Small grain is the main crop.

Representative profile of Fulda silty clay loam, 350 feet south and 130 feet east of the northwest corner of sec. 12, T. 161 N., R. 87 W., in a cultivated field.

Ap—0 to 5 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; moderate, fine, subangular blocky structure; hard, friable, sticky and plastic; neutral; abrupt, smooth boundary.

B2—5 to 15 inches, very dark grayish-brown (2.5Y 3/2) silty clay, dark gray (10YR 4/1) when dry; few, medium, faint, light olive-brown (2.5Y 5/4) mottles; moderate, fine, subangular blocky structure; very hard, firm; very sticky and very plastic; neutral; clear, wavy boundary.

B3—15 to 29 inches, mixed grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/5) silty clay, grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/5) when dry; moderate, very fine, subangular blocky structure; very hard, firm, very sticky and very plastic; slight effervescence; mildly alkaline; gradual boundary.

C—29 to 60 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) clay loam, light yellowish brown (2.5Y 6/4) when dry; common, fine, prominent, yellowish-brown (10YR 5/6) mottles; massive; hard, firm, sticky and plastic; strong effervescence; moderately alkaline.

The A horizon is very dark gray or black and 5 to 8 inches thick. The B horizon is silty clay or silty clay loam.

Fulda soils are in positions similar to those of Parnell and Tonka soils. They have a thinner A horizon and solum than Parnell soils and lack an A2 horizon, which Tonka soils have.

Fu—Fulda silty clay loam. This soil is level and is in shallow depressions and on flats of glacial till plains. The slope is 0 to 1 percent. Included with this soil in mapping were small areas of Tonka silt loam.

Runoff is very slow. This soil is ponded for a few days to several weeks in spring or after heavy rain. During the middle and later parts of the growing season, the water table is 1 foot to 3 feet below the surface in most years.

Most of the drainage is cultivated. If drained, this soil is well suited to cultivated crops, but some areas are too wet unless excess water is removed. Spring seeding is delayed by wetness in most years. Wetness is the main concern of management. Capability unit IIIw–6; windbreak suitability group 2.

Gravel Pits

Gp—Gravel pits. This land type consists of irregularly shaped areas of excavated gravel pits and dumps more than 2 acres in size. The smaller areas are shown on the detailed soil map by a spot symbol.

Most areas of Gravel pits are barren. The pits are mainly in gravel and sand, and the dumps are mixed stones, cobbles, gravel, sand, and finer textured soil material. Some areas have a high water table.

Other than as a source of sand and gravel, gravel pits are well suited to and used mainly for wildlife habitat. Some have a high water table and are suited to special tree plantings for wildlife. If extensive leveling and reclamation are done, some areas are suited to grasses or crops. Capability unit VIIIs 1; windbreak suitability group 10.

Great Bend Series

The Great Bend series consists of deep, well-drained, nearly level soils. These soils are in glacial lake basins and on lake plains. They formed in calcareous, loamy, lacustrine sediment.

In a representative profile the surface layer is black silty clay loam about 7 inches thick. The subsoil is very dark grayish-brown firm silty clay loam about 8 inches thick. The underlying material, to a depth of about 60 inches, is grayish-brown silty clay loam about 9 inches thick over dark grayish-brown clay loam that is mottled in the lower part.

Permeability is moderate, and the available water capacity is high. Runoff is medium. The fertility and content of organic matter are high.

Nearly all areas are cultivated and used for small grain. These soils are suited to all crops commonly grown in the county.

Representative profile of Great Bend silty clay loam, 1 to 3 percent slopes, 200 feet east and 85 feet north of the southwest corner of sec. 21, T. 161 N., R. 85 W., in a cultivated field.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; strong, fine and very fine, crumb structure; slightly hard, friable, sticky and plastic; neutral; abrupt, smooth boundary.

B2—7 to 15 inches, very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) when dry; moderate, medium, prismatic structure parting to moderate, medium, angular blocky; hard, firm, sticky and plastic; faces of peds coated with dark grayish brown (10Y 4/2) when dry; neutral; clear, wavy boundary.

C1ca—15 to 24 inches, grayish-brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) when dry; weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; hard, friable, very sticky and very plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

C2ca—24 to 36 inches, dark grayish-brown (2.5Y 4/2) clay loam, light brownish gray (2.5Y 6/2) when dry; massive; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

C3—36 to 60 inches, dark grayish-brown (2.5Y 4/2) clay loam, light brownish gray (2.5Y 6/2) when dry; many, medium, distinct, dark yellowish-brown (10YR 4/4) mottles in the lower 12 inches; massive; hard, firm, sticky and plastic; strong effervescence; few nests of gypsum; moderately alkaline.

Thickness of the solum and, in most places, depth to lime range from 13 to 18 inches. The B2 horizon has weak to moderate, prismatic structure parting to weak to strong, blocky. In places the lower part of the B horizon has few to common mottles of high chroma. In places the C horizon has loam glacial till below a depth of 40 inches.

Great Bend and Fargo soils are in similar topographic positions, but Great Bend soils have more silt and less clay than Fargo soils. Great Bend soils are near Barnes soils, but they have more silt and less sand.

GrA—Great Bend silty clay loam, 1 to 3 percent slopes. This soil is nearly level and is in lake basins and on flats on glacial till plains. Included with this soil in mapping were some small areas of moderately well drained soils and a few small areas of Barnes and Hamlet soils.

Runoff is slow. This soil is slightly susceptible to soil blowing.

Nearly all the acreage is used for small grain, but the soil is suited to all crops commonly grown in the county. Controlling soil blowing and maintaining fertility and the content of organic matter are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

Hamerly Series

The Hamerly series consists of deep, moderately well drained, nearly level and undulating soils. These soils are in slightly convex areas around shallow basins and on slight rises of ground moraine on glacial till plains. They formed in loamy glacial till and are limy at or near the surface.

In a representative profile the surface layer is very dark gray loam about 6 inches thick. The underlying material, to a depth of about 19 inches, is light olive-brown loam that contains a large amount of lime. Below this, to a depth of about 60 inches, is olive-brown loam that contains a moderate amount of lime and that is mottled in the lower part.

Permeability is moderately slow, and the available water capacity is high. Runoff is medium to slow. The content of organic matter is moderate, and fertility is high. The water table is within 3 to 5 feet of the surface in spring in most years.

Most areas are cultivated and used for small grain. These soils are suited to all crops commonly grown in the county.

Representative profile of Hamerly loam, 1 to 3 percent slopes, 2,000 feet north and 150 feet east of the southwest corner of sec. 8, T. 158 N., R. 82 W., in a cultivated field.

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) when dry; moderate, fine, crumb structure; slightly hard, friable, sticky and plastic; strong effervescence; moderately alkaline; clear, smooth boundary.

C1ca—6 to 19 inches, light olive-brown (2.5Y 5/4) loam, light gray (2.5Y 7/2) when dry; massive; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; gradual boundary.

C2—19 to 32 inches, olive-brown (2.5Y 4/4) loam, pale olive (5Y 6/3) when dry; massive; hard, friable, sticky and plastic; strong effervescence; moderately alkaline; gradual boundary.

C3cs—32 to 60 inches, olive-brown (2.5Y 4/3) loam, pale olive (5Y 6/3) when dry; few, fine, prominent, gray (5Y 5/1) mottles, light gray (5Y 7/1) when dry; massive; hard, firm, sticky and plastic; few, large, prominent, light olive-gray (5Y 6/2) nests of gypsum; strong effervescence; moderately alkaline.

The A1 horizon is very dark gray or black and is 6 to 8 inches thick. It has slight effervescence, if any, in areas of native grass but strong or violent effervescence in cultivated areas. In places all or part of the C horizon is light clay loam. In a few places tongues of the A1 horizon extend into the upper part of the C horizon. Masses of gypsum in the C3 horizon are common in most places.

Hamerly soils are associated on the landscape with Vallers and Barnes soils. They are better drained and have mottles at a greater depth than Vallers soils. They are not so well drained as Barnes soils, have lime at less depth, and lack a B2 horizon, which Barnes soils have.

HaA—Hamerly loam, 1 to 3 percent slopes. This soil is nearly level. It is in low-lying areas that border elongated depressions or potholes and between depressions in the glacial till plain. It has the profile described as representative of the series. Included with it in mapping were small areas of Vallers loam and Tonka silt loam

Runoff is slow. This soil is highly susceptible to soil blowing.

This soil is used mainly for cultivated crops, but it is suited to all crops commonly grown in the county. Wetness delays spring seeding in some years. Controlling soil blowing and wetness and maintaining fertility and the content of organic matter are the main concerns of management. Capability unit IIe–4L; windbreak suitability group 1.

HbA—Hamerly-Tonka loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are in low areas on glacial till plains. About 65 percent of the complex is Hamerly loam, and 35 percent is Tonka silt loam. The Hamerly soil is in slightly higher, convex areas around and between basins, and the Tonka soil is in shallow basins (fig. 9). The Hamerly soil has a higher content of lime and is not so wet as the Tonka soil.

Runoff is generally slow, but the Tonka soil is subject to ponding.

This complex is used mainly for cultivated crops. Spring seeding has to be delayed in most years because the soils are wet. Soil blowing on the Hamerly soil and wetness on the Tonka soil are special concerns of management. The soils are suited to cultivated crops if excess water is removed. Capability unit IIe-4L; Hamerly soil in windbreak suitability group 1; Tonka soil in windbreak suitability group 2.

Figure 9.—**Area of Hamerly-Tonka loams, 1 to 3 percent slopes.**

Hamlet Series

The Hamlet series consists of deep, moderately well drained, nearly level to undulating soils. These soils are in plane and slightly concave areas on till plains. They formed in loamy glacial till.

In a representative profile the surface layer is black loam about 8 inches thick. The subsoil is friable, mottled loam about 11 inches thick. It is very dark grayish brown in the upper part and dark grayish brown in the lower part. The underlying material is mottled light olive-brown loam to a depth of about 37 inches and mottled olive-brown loam to a depth of about 60 inches.

Permeability is moderate in the subsoil and slow in the underlying material. The available water capacity is high. Runoff is medium to slow. The fertility and content of organic matter are high.

Most areas are cultivated and used for small grain. These soils are suited to all crops commonly grown in the county.

Representative profile of Hamlet loam, in an area of Barnes-Hamlet-Tonka loams, 1 to 3 percent slopes, 900 feet east and 25 feet south of the northwest corner of sec. 5, T. 161 N., R. 85 W.

Ap—0 to 8 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak and moderate, medium and very fine, subangular blocky structure; hard, and very friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

B21—8 to 15 inches, very dark grayish-brown (10YR 3/2) loam, grayish brown (10YR 5/2) when dry; common, fine, faint, brown (10YR 5/3) mottles in the lower part; moderate, medium, prismatic structure parting to moderate, medium and fine, angular blocky; hard, friable, sticky and plastic; few thin tongues of material from the A1 horizon; few, thin, dark-gray (10YR 4/1) coatings on faces of prisms; few pebbles; neutral; clear, irregular boundary.

B22—15 to 19 inches, dark grayish-brown (2.5Y 4/2) loam, light brownish gray (2.5Y 6/2) when dry; common, faint, gray mottles and common, distinct, light olive-brown (2.5Y 5/4) mottles; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; hard, friable, slightly sticky and slightly plastic; few stones; slight effervescence; few small accumulations of lime; mildly alkaline; clear, irregular boundary.

C1ca—19 to 37 inches, light olive-brown (2.5Y 5/4) loam, light gray (2.5Y 7/2) when dry; common, medium, distinct, gray and light-gray (N 7/0 and 5/0) mottles; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; hard, friable, slightly sticky and slightly plastic; few pebbles; common soft masses of lime; violent effervescence; moderately alkaline; clear, wavy boundary.

C2—37 to 60 inches, olive-brown (2.5Y 4/4) loam, light yellowish brown (2.5Y 6/4) when dry; common, medium, distinct, light yellowish-brown (2.5Y 6/4) mottles and few, fine, prominent, strong-brown (7.5YR 5/6) mottles; massive but parts to weak, medium, subangular blocky and laminar structure; very hard, firm, sticky and slightly plastic; few pebbles; strong effervescence; common crystals of gypsum in the lower part; moderately alkaline.

The thickness of the solum and depth to lime is 13 to 20 inches. The A1 horizon is black or very dark gray. In most places the B2 horizon has few to many, faint or distinct mottles, mainly in the lower part. The B2 horizon has weak to strong, prismatic structure that parts readily to angular or subangular blocky. Clay films are lacking or are patchy on faces of peds. The C2 horizon has few to many crystals of gypsum in most places.

Hamlet soils are associated with Barnes and Svea soils. They are not so well drained as Barnes soils and are not dark colored to so great a depth as Svea soils.

HhA—Hamlet-Hamerly-Tonka loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are on the till plain on low flats and in broad drainageways, in which are shallow basins. About 55 percent of the complex is Hamlet loam, 25 percent is Hamerly loam, and 20 percent is Tonka silt loam. The Hamlet soil is in the higher, concave areas, the Hamerly soil is in the areas around and between depressions, and the Tonka soil is in the depressions. The Hamlet soil has a lower content of lime than the Hamerly soil, and both are less wet than the Tonka soil.

Runoff is generally slow, but the Tonka soil is subject to ponding.

Most areas of this complex are used for crops. Spring seeding is delayed on the Tonka soil in most years unless excess water has been removed. Soil blowing on the Hamerly soil is a special concern of management. This complex is suited to cultivated crops if excess water is removed. Capability unit IIc–6; Hamlet and Hamerly soils in windbreak suitability group 1; Tonka soil in windbreak suitability group 2.

HmA—Hamlet-Tonka loams, 1 to 3 percent slopes. The soils making up this complex are nearly level and are on the till plain in elongated swales and broad drainageways in which are shallow basins. About 65 percent of the complex is Hamlet loam, 25 percent is Tonka silt loam, and 10 percent is areas of Hamerly loam. The Hamlet soil is on plane and slightly concave side slopes, the Tonka soil is in depressions, and the included Hamerly soil is on slightly convex and plane side slopes. The Hamlet soil has a lower content of lime than the Hamerly soil, and both are less wet than the Tonka soil.

Runoff is generally slow, but the Tonka soil is subject to ponding.

Nearly all the acreage is used for crops. Wetness is the main concern of management. Spring seeding is delayed on the Tonka soil in most years, unless excess water has been removed. This complex is suited to cultivated crops if excess water is removed. Capability unit IIc–6; Hamlet soil in windbreak suitability group 1; Tonka soil in windbreak suitability group 2.

Hecla Series

The Hecla series consists of deep, moderately well drained, nearly level soils. These soils are in plane and slightly concave positions on outwash plains. They formed in sandy glacial outwash.

In a representative profile the surface layer is very dark gray loamy sand about 16 inches thick. Beneath the surface layer is about 8 inches of very friable, very dark grayish-brown loamy sand. The underlying material is light olive-brown loamy sand to a depth of about 40 inches and light olive-brown fine and medium sand to a depth of about 60 inches.

Permeability is rapid, and the available water capacity is low. Runoff is slow. The content of organic matter is moderately low, and fertility is low.

These soils are used mainly for tame grass and alfalfa. Some areas are used for cultivated crops and are highly susceptible to soil blowing. Hecla soils are better suited to grass and legumes than to most other crops.

Representative profile of Hecla loamy sand, in an area of Hecla and Lohnes loamy sands, 1 to 3 percent slopes, 990 feet west of the northeast corner of sec. 8, T. 158 N., R. 84 W., in a cultivated area.

Ap—0 to 7 inches, very dark gray (10YR 3/1) loamy sand, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, medium, crumb; slightly hard, very friable, nonsticky and nonplastic; neutral; abrupt, smooth boundary.

A12—7 to 16 inches, very dark gray (10YR 3/1) loamy sand, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, medium, crumb; slightly hard, very friable, nonsticky and nonplastic; neutral; clear, wavy boundary.

AC—16 to 24 inches, very dark grayish-brown (10YR 3/2) loamy sand, grayish brown (10YR 5/2) when dry; weak, medium, subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; mildly alkaline; clear, wavy boundary.

C1ca—24 to 40 inches, light olive-brown (2.5Y 5/4) loamy sand, pale yellow (2.5Y 7/4) when dry; single grained; slightly hard, very friable, nonsticky and nonplastic; violent effervescence; moderately alkaline; gradual boundary.

C2—40 to 60 inches, light olive-brown (2.5Y 5/4) medium and fine sand, light yellowish brown (2.5Y 6/4) when dry; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline.

The solum is loamy fine sand, loamy sand, or fine sand 16 to 40 inches thick. Depth to lime ranges from 20 to more than 60 inches. The A1 horizon is very dark gray or black. In places the C horizon, below a depth of 40 inches, is finer textured than loamy fine sand or coarser textured than fine sand.

Hecla soils are finer textured below the AC horizon than Lohnes soils and coarser textured than Embden soils. Also, they lack a B horizon, which Embden soils have.

HoA—Hecla and Lohnes loamy sands, 1 to 3 percent slopes. The soils making up this undifferentiated unit are nearly level and are on sandy outwash plains. Some areas consist of Hecla loamy sand, some consist of Lohnes loamy sand, and some contain both. Both soils have the profiles described as representative of their series. Runoff is slow.

Most of the acreage is in tame grass and pasture. The main concerns of management are soil blowing and droughtiness. Many cultivated areas have small blowout spots, and these areas are not well suited to small grain. Capability unit IVe–2; the Hecla soil is in windbreak suitability group 1; the Lohnes soil is in windbreak suitability group 7.

LaDelle Series

The LaDelle series consists of deep, moderately well drained, nearly level, loamy soils. These soils are on flood plains of the Souris and Des Lacs Rivers.

In a representative profile the upper 8 inches of the surface layer is black silty clay loam, and the lower 18 inches is very dark grayish-brown, silty clay loam. The underlying material, to a depth of about 40 inches, is mottled dark grayish-brown stratified very fine sandy loam and loam. Below this, it is stratified olive-brown and light olive-brown fine and medium sand.

Permeability is moderate, and the available water capacity is high. Runoff is slow (fig. 10). The content of organic matter is moderate, and fertility is high. These soils are occasionally flooded in spring.

Figure 10.—**Flooded areas of bottom lands along the Souris River. The water covers areas of LaDelle, Ludden, and Velva soils.**

LaDelle soils are used mainly for cultivated crops. They are suited to all crops commonly grown in the county. Some areas are in native woodland and grass.

Representative profile of LaDelle silty clay loam, 1 to 3 percent slopes, 750 feet north of the southeast corner of sec. 15, T. 163 N., R. 87 W., in a cultivated field.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to moderate, fine, granular; friable, sticky and plastic; slight effervescence; mildly alkaline; clear, smooth boundary.

A12—8 to 26 inches, very dark grayish-brown (2.5Y 3/2) silty clay loam, very dark gray (10YR 3/1) and grayish brown (2.5Y 5/2) when dry; weak, coarse, subangular blocky structure; friable, sticky and plastic; slight effervescence; mildly alkaline; gradual, wavy boundary.

C1—26 to 30 inches, dark grayish-brown (2.5Y 4/2) very fine sandy loam, light brownish gray (2.5Y 6/2) when dry; few, fine, faint, dark yellowish-brown (10YR 4/4) mottles; very friable, nonsticky and nonplastic; slight effervescence; mildly alkaline; irregular boundary.

C2—30 to 40 inches, dark grayish-brown (2.5Y 4/2) loam, light brownish gray (2.5Y 6/2) when dry; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; very friable, nonsticky and nonplastic; slight effervescence; mildly alkaline; irregular boundary.

C3—40 to 45 inches, olive-brown (2.5Y 4/4) fine sand, light brownish gray (2.5Y 6/2) when dry; single grained; very friable, nonsticky and nonplastic; slight effervescence; mildly alkaline; irregular boundary.

C4—45 to 60 inches, light olive-brown (2.5Y 5/4) medium sand, light gray (2.5Y 7/2) when dry; single grained; very friable, nonsticky and nonplastic; slight effervescence; mildly alkaline.

A buried A horizon is below a depth of 20 inches in many places. The A1 horizon is black or very dark gray silt loam or silty clay loam 12 to 28 inches thick. The soil material below the A1 horizon to a depth of 40 inches is silty clay loam, silt loam, loam, or very fine sandy loam that averages 25 to 35 percent clay and less than 15 percent fine sand and coarser sand.

LaDelle soils are associated with Ludden and Velva soils. They are better drained and contain less clay than Ludden soils. They are not so well drained as Velva soils and contain more clay.

LaA—LaDelle silty clay loam, 1 to 3 percent slopes. This soil is nearly level and is on flood plains of the Des Lacs and Souris Rivers.

Runoff is slow. In some years the soil is flooded for a few days in spring.

This soil is suited to all crops commonly grown in the county, and most areas are used for cultivated crops. Some areas are in native woodland or grass. Flooding is a concern of management. Soil blowing and erosion are easily controlled. Capability unit IIc–6; windbreak suitability group 1.

Lohnes Series

The Lohnes series consists of deep, moderately well drained, nearly level and undulating soils. These soils are mainly on outwash plains. They formed in sandy glacial outwash.

In a representative profile the surface layer is black loamy sand about 11 inches thick. The next layer is very friable very dark brown loamy sand about 4 inches thick. The underlying material, to a depth of about 60 inches, is loose brown sand.

Permeability is rapid, and the available water capacity is low. Runoff is slow. The content of organic matter is moderately low, and fertility is low.

Lohnes soils are used mainly for tame grass and alfalfa. Some areas are used for cultivated crops and are very susceptible to soil blowing. These soils are better suited to grass and legumes than to other uses.

Representative profile of Lohnes loamy sand, in an area of Hecla and Lohnes loamy sands, 1 to 3 percent slopes, 300 feet east and 30 feet south of the northwest corner of sec. 23, T. 163 N., R. 84 W.

A1—0 to 11 inches, black (10YR 2/1) loamy sandy, very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure parting to single grained; soft, very friable, nonsticky and nonplastic; neutral; clear, wavy boundary.

AC—11 to 15 inches, very dark brown (10YR 2/2) loamy sand, very dark grayish brown (10YR 3/2) when dry; weak, medium, subangular blocky structure parting to single grained; soft, very friable, nonsticky and nonplastic; slight effervescence; mildly alkaline; clear, wavy boundary.

C1—15 to 34 inches, brown (10YR 5/3) sand, pale brown (10YR 6/3) when dry; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline; gradual, wavy boundary.

C2—34 to 60 inches, brown (10YR 4/3) sand, pale brown (10YR 6/3) when dry; lenses of yellowish brown (10YR 5/4); single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline.

The A1 horizon is black, very dark gray, or very dark brown and 10 to 20 inches thick. The AC horizon is loamy sand or coarser textured. The C horizon is sand or coarse sand.

Lohnes soils are coarser textured below the AC horizon than Hecla soils. They are coarser textured than Embden soils, and they lack a B horizon, which Embden soils have.

LoB—Lohnes loamy sand, 3 to 6 percent slopes. This soil is undulating and is on sandy glacial outwash plains. Included with it in mapping were small areas of Hecla loamy sand in swales.

Runoff is slow. This soil is droughty and highly susceptible to soil blowing. In most cultivated areas there are small blowout spots.

This soil is suited to grass and legumes, but it is poorly suited to cultivated crops. Most areas are used for tame grass and alfalfa. Soil blowing and droughtiness are the main concerns of management. Capability unit IVe–2; windbreak suitability group 7.

Ludden Series

The Ludden series consists of deep, poorly drained, level clayey soils. These soils are on bottom lands of the Des Lacs and Souris Rivers.

In a representative profile the surface layer is very dark gray silty clay about 24 inches thick. The underlying material, to a depth of about 60 inches, is silty clay. In sequence from the top, the upper 15 inches is very dark grayish brown, the next 8 inches is dark grayish brown, and the lower 13 inches is very dark grayish brown.

Permeability is slow, and the available water capacity is high. Runoff is slow or very slow. The content of organic matter is moderate, and fertility is high. These soils are flooded in most years and are ponded for a few days to several weeks. For most of the year, the water table is 1 foot to 3 feet below the surface.

About half the acreage is used for cultivated crops, and half is in native grass and native woodland. These soils are suited to cultivated crops, if excess water is removed.

Representative profile of Ludden silty clay, 115 feet south and 400 feet west of the northeast corner of sec. 29, T. 162 N., R. 86 W., in native grass.

A11—0 to 11 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; weak, medium, angular blocky structure parting to moderate, medium, granular; very hard, firm, sticky and plastic; mildly alkaline; gradual, wavy boundary.

A12—11 to 17 inches, very dark gray (10YR 3/1) silty clay, gray (10YR 5/1) when dry; moderate, medium and fine, angular blocky structure parting to strong, medium, granular; very hard, firm, sticky and plastic; slight effervescence; mildly alkaline; gradual, wavy boundary.

A13—17 to 24 inches, very dark gray (10YR 3/1) silty clay, gray (10YR 5/1) when dry; moderate, medium and fine, angular blocky structure parting to strong, medium, granular; hard, firm, sticky and plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C1ca—24 to 39 inches, very dark grayish-brown (2.5Y 3/2) silty clay, gray (5Y 5/1) when dry; strong, fine, angular blocky structure; stratified in the lower part; very hard, firm, sticky and plastic; violent effervescence; common white (2.5Y 8/2) nodules of lime; moderately alkaline; gradual, wavy boundary.

C2ca—39 to 47 inches, dark grayish-brown (2.5Y 4/2) silty clay, grayish brown (2.5Y 5/2) when dry; massive; stratified; hard, friable, sticky and plastic; violent effervescence; many white threads and nodules of lime; moderately alkaline; gradual, wavy boundary.

C3ca—47 to 60 inches, very dark grayish-brown (2.5Y 3/2) silty clay, grayish brown (2.5Y 5/2) when dry; massive; stratified; hard, friable, sticky and plastic; strong effervescence; many white threads and nodules of lime; moderately alkaline.

The dark-colored surface layer is 24 to 36 inches thick. The dominant texture between depths of 10 and 40 inches is silty clay or clay. Some profiles are calcareous throughout. The A horizon is very dark gray or black. It is generally silty clay, but in places it is clay. The C horizon has a hue of 2.5Y or 5Y, a value of 2 to 4 when moist and 3 to 5 when dry, and a chroma of 1 or 2. Some profiles are mottled.

Ludden soils are more poorly drained and contain more clay than LaDelle and Velva soils.

Lu—Ludden silty clay. This soil is on bottom lands of the Souris and Des Lacs Rivers. It has slopes of 0 to 1 percent. This soil has the profile described as representative of the series.

Runoff is slow or very slow. In most years this soil is flooded in spring and remains ponded for a few days. Unprotected cultivated areas are highly susceptible to soil blowing in spring.

This soil is suited to crops and grass used for hay and pasture. About half of the acreage is cropped, and half is in native woodland and grass used for pasture and hay. This soil has poor tilth if it is too dry or too wet. Wetness, soil blowing, and poor tilth are the main concerns of management. Capability unit IIw–4; windbreak suitability group 1.

Ly Ludden silty clay, very wet. This soil is in old oxbows and abandoned stream channels of the Souris River. It has slopes of 0 to 3 percent. The slopes are level and nearly level in most places, but are gently sloping on some terrace edges. The soil has a profile similar to the one described as representative of the series, but the surface layer is slightly thicker and has a higher content of organic matter. This soil is also wetter than the representative Ludden soil.

In most years this soil is too wet to cultivate. It is better suited to hay and pasture than to most other crops. Most of the acreage is used for hay. A few areas that have been drained are used for crops, but most areas lack drainage outlets. Capability unit Vw–4; windbreak suitability group 10.

Marsh

Ma—Marsh. This land type is covered by water most of the year. The water in most of the areas is not saline. The vegetation is bullrushes and cattails.

Areas of Marsh occur naturally throughout the glacial till plain. Some areas have been developed in the Upper Souris National Wildlife Refuge (fig. 11). Marsh is excellent habitat for wildlife, but it has little value for farming. Capability unit VIIIw 1; windbreak suitability group 10.

Marysland Series

The Marysland series consists of poorly drained, level, loamy soils. These soils are on glacial outwash plains. They have sand and gravel at a depth of 20 to 40 inches and are limy throughout.

In a representative profile the surface layer is very dark gray silt loam about 7 inches thick. The underlying material, to a depth of about 35 inches, is silt loam. The upper part is mottled light brownish gray and light gray, the middle part is grayish brown and light brownish gray, and the lower part is mottled light olive brown. Below this, to a depth of about 60 inches, is mottled light olive-brown fine sand about 10 inches thick over olive-brown gravelly coarse sand.

Permeability is moderate in the upper part of the soil and very rapid in the lower part. The available water capacity is moderate. Runoff is slow. The content of organic matter and fertility are high. The water table fluctuates between depths of less than 1 foot in spring and 4 feet or more late in summer.

Figure 11.—**Marsh area at the north end of Lake Darling.**

Most areas are used for hay and pasture. Marysland soils are better suited to these uses than to others.

Representative profile of Marysland silt loam, 1,380 feet west and 90 feet north of the southeast corner of sec. 15, T. 162 N., R. 84 W., in a cultivated field.

Ap—0 to 7 inches, very dark gray (10YR 3/1) silt loam, dark gray (10YR 4/1) when dry; weak, fine, subangular blocky structure; very friable; slightly sticky and slightly plastic; strong effervescence; moderately alkaline; abrupt, wavy boundary.

C1ca—7 to 15 inches, light brownish-gray and light-gray (2.5Y 6/2 and 7/2) silt loam, white (N 8/0) when dry; common, medium, distinct, pale-olive (5Y 6/3) mottles; moderate, fine, subangular blocky structure; friable, slightly sticky and plastic; violent effervescence; moderately alkaline; clear, wavy boundary.

C2ca—15 to 20 inches, grayish-brown and light brownish-gray (2.5Y 5/2 and 6/2) silt loam, light gray (5Y 7/2) when dry; moderate, fine, subangular blocky structure; very friable, nonsticky and slightly plastic; violent effervescence; many root pores; moderately alkaline; clear, wavy boundary.

C3—20 to 35 inches, light olive-brown (2.5Y 5/4) silt loam, light yellowish brown (2.5Y 6/4) when dry; common, medium, distinct, grayish-brown (2.5Y 5/2) mottles; weak, fine, subangular blocky structure; very friable, nonsticky and slightly plastic; strong effervescence; many root pores; moderately alkaline; clear, wavy boundary.

IIC4—35 to 45 inches, light olive-brown (2.5Y 5/6) fine sand, yellow (2.5Y 7/6) when dry; common, large, distinct, dark yellowish-brown (10YR 4/4) mottles; single grained; loose, nonsticky and nonplastic; slight effervescence; moderately alkaline; abrupt, wavy boundary.

IIIC5—45 to 60 inches, olive-brown (2.5Y 4/4) gravelly coarse sand, light brownish gray (2.5Y 6/2) when dry; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline.

Depth to sand and gravel ranges from 20 to 40 inches. The black or very dark gray A1 horizon ranges from 5 to 12 inches in thickness. The Cca horizon is 10 to 20 inches thick. Part or all of the C horizon is mottled.

Marysland soils are coarser textured at a depth of 20 to 40 inches than Arveson and Colvin soils.

Mb—Marysland silt loam. This soil is on lowland areas of glacial outwash. It has slopes of 0 to 1 percent. Included with it in mapping were natural drainage channels that have short, steep side slopes and small areas of a soil that has sand and gravel at a depth of more than 40 inches.

Runoff is slow. In cultivated areas the soil is susceptible to soil blowing.

This soil is better suited to grass than to other crops. Most areas are used for pasture and hay. The soil is fairly well suited to cultivated crops if the water table is lowered. Most areas lack adequate drainage outlets. Wetness and soil blowing are the main concerns of mangement. Capability unit IVw 4L; windbreak suitability group 2.

Max Series

The Max series consists of deep, well-drained, rolling to very steep soils. These soils are on the coulee breaks along the Souris and Des Lacs Rivers. They formed in glacial till.

In a representative profile the surface layer is very dark brown loam about 4 inches thick. The subsoil is very dark grayish-brown, friable loam about 9 inches thick. The underlying material, to a depth of about 25 inches, is light olive-brown loam that has a large amount of lime. Below this, to a depth of about 60 inches, it is olive-brown loam.

Permeability is moderate in the subsoil and moderately slow in the underlying material. The available water capacity is high. Runoff is rapid. The content of organic matter is moderate, and fertility is high.

Nearly all the acreage is in native grass used for pasture. These soils are suited to pasture and wildlife habitat.

Representative profile of Max loam, in an area of Zahl-Max loams, 9 to 15 percent slopes, 1,055 feet east and 75 feet south of the northwest corner of sec. 25, T. 163 N., R. 87 W., in grass.

A1—0 to 4 inches, very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) when dry; weak, medium and fine, crumb structure; friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

B2—4 to 13 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) when dry; moderate, medium and fine, angular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; gradual, wavy boundary.

Clca —13 to 25 inches, light olive-brown (2.5Y 5/4) loam, pale olive (5Y 6/3) when dry; many light-gray (2.5Y 7/2) masses of lime; moderate, medium and fine, subangular blocky structure; friable, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

C2—25 to 60 inches, olive-brown (2.5Y 4/4) loam, pale olive (5Y 6/3) when dry; massive; friable, sticky and plastic; strong effervescence; moderately alkaline.

The solum ranges from 12 to 20 inches in thickness. In a few cultivated areas, the Ap horizon is very dark grayish brown when moist and dark grayish brown when dry. The A1 horizon ranges from 3 to 7 inches thick. The B2 horizon has weak to moderate, medium or coarse, prismatic structure parting to fine to coarse, blocky. Lime occurs both in diffuse forms and in segregations of threads and masses.

Max soils are near Williams and Zahl soils. They have less clay in the B2 horizon than Williams soils. They have a thicker solum than Zahl soils, and they have a B2 horizon, which Zahl soils lack.

Parnell Series

The Parnell series consists of deep, very poorly drained, level soils that have a clayey subsoil. These soils are in closed basins on glacial till plains. They formed in glacial alluvium.

In a representative profile the surface layer is black silty clay loam about 9 inches thick. The subsoil is mottled, firm silty clay about 25 inches thick. It is black in the upper part and very dark gray in the lower part. The underlying material, to a depth of about 60 inches, is olive-gray silty clay in the upper part and gray and olive-brown clay loam in the lower part.

Permeability is slow, and the available water capacity is high. Fertility and the content of organic matter are high. These soils ponded for most of the growing season in wet years. A seasonal high water table is within 1 foot to 3 feet of the surface.

Parnell soils are better suited to late-season native pasture and hay and wildlife habitat than to other uses. They are suited to and are used for cultivated crops if excess water is removed.

Representative profile of Parnell silty clay loam, 330 feet south and 960 feet west of the northeast corner of sec. 23, T. 158 N., R. 82 W., in native meadow.

A11—0 to 4 inches, black (10 YR 2/1) silty clay loam; moderate, fine, crumb structure; friable, sticky and plastic; neutral; clear boundary.

A12—4 to 9 inches, black (10 YR 2/1) silty clay loam; strong, fine, granular structure; friable, sticky and plastic; neutral; clear boundary.

B21t—9 to 22 inches, black (10 YR 2/1) silty clay; many, fine, distinct, light olive-brown mottles; strong, fine, angular blocky structure; firm, very sticky and very plastic; neutral; gradual boundary.

B22tg—22 to 34 inches, very dark gray (N 3/0) silty clay; few, prominent, dark-colored mottles; massive; firm, very sticky and very plastic; neutral; clear, irregular boundary.

C1g—34 to 44 inches, olive-gray (5Y 5/2) silty clay; massive; firm; very sticky and very plastic; strong effervescence; mildly alkaline; gradual boundary.

IICzg—44 to 60 inches, gray and olive-brown (5Y 5/1 and 2.5Y 4/4) clay loam; massive; friable, sticky and plastic; strong effervescence; mildly alkaline.

The solum ranges from 30 to 50 inches in thickness. It contains small snail shells in many places. The A1 horizon is silty clay loam or silt loam 6 to 12 inches thick. The B2t horizon is heavy silty clay loam to clay and, in some places, is not mottled. The Cg horizon, below a depth of 40 inches, is loamy glacial till in many places. In some places it has weak, blocky structure.

Parnell soils are in areas similar to those in which Fulda and Tonka soils occur. They have a thicker A1 horizon and solum than Fulda soils and lack a thick A2 horizon, which Tonka soils have.

Pa—Parnell silty clay loam. This soil is in closed depressions on glacial till plains (fig. 12). It has slopes of 0 to 1 percent.

This soil is ponded during most of the growing season in wet years unless excess water is removed. Many basins do not have adequate drainage outlets.

This soil is suited to late-season pasture and hay and wildlife habitat. Areas where excess water has been removed are suited to cultivated crops. Most areas are used for native pasture and hay. Wetness is the main concern of management. Capability unit IIIw–6; windbreak suitability group 2.

Renshaw Series

The Renshaw series consists of somewhat excessively drained, nearly level and gently sloping, loamy soils. These soils have plane and short convex slopes. They are on glacial outwash plains. Sand and gravel are at a depth of 10 to 20 inches.

In a representative profile (fig. 13) the surface layer is black loam about 5 inches thick. The very dark grayish-brown subsoil is about 11 inches thick. It is friable loam in the upper part and loose sandy loam and gravelly loam in the lower part. The underlying material, to a depth of about 60 inches, is sand and gravel that is dark grayish brown in the upper part and brown in the lower part.

Permeability is moderate in the upper part of the soil and very rapid in the lower part. The available water capacity is moderate. Runoff is slow to medium. The content of organic matter is moderate, and fertility is medium. The root zone is restricted to the upper few

Figure 12.—**Parnell silty clay loam in a depression.**

inches of the underlying material, which is sand and gravel. These soils are droughty.

Most areas are cultivated. These soils are fairly well suited to cultivated crops, but they are better suited to pasture.

Representative profile of Renshaw loam, 1 to 3 percent slopes, 4,000 feet east and 420 feet south of the northwest corner of sec. 31, T. 164 N., R. 84 W., in a cultivated field.

Ap—0 to 5 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, medium, crumb; slightly hard, very friable, nonsticky and slightly plastic; neutral; abrupt, smooth boundary.

B2—5 to 11 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) when dry; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, sticky and plastic; neutral; abrupt, wavy boundary.

B3—11 to 16 inches, very dark grayish-brown (10YR 3/2) sandy loam and gravelly loam, dark grayish brown (10YR 4/2) when dry; weak, medium, subangular blocky structure; loose, nonsticky and nonplastic; neutral; clear, wavy boundary.

IIC1—16 to 40 inches, dark grayish-brown (10YR 4/2) gravel and sand, light brownish gray (10YR 6/2) when dry; single grained; loose, nonsticky and nonplastic; strong effervescence; mildly alkaline; gradual, wavy boundary.

IIC2—40 to 60 inches, brown (10YR 4/3) gravel and sand, pale brown (10YR 6/3) when dry; single grained; loose, nonsticky and nonplastic; slight effervescence; mildly alkaline.

Thickness of the solum and depth to sand and gravel range from 10 to 20 inches. The A1 horizon is black or very dark gray and ranges from 4 to 7 inches in thickness. The B2 horizon is very dark grayish brown or very dark brown. It has weak to moderate, medium to coarse, prismatic structure that parts to weak to moderate, fine to medium, subangular blocky. A B3 horizon is lacking in places. The IIC1 horizon has a weakly expressed zone of lime accumulation, where the lime occurs in the form of crusts and coatings on pebbles.

Renshaw soils are near Arvilla and Sioux soils. They have less sand in the B horizon than Arvilla soils. They have a thicker solum over sand and gravel than Sioux soils.

RnA—Renshaw loam, 1 to 3 percent slopes. This soil is nearly level and is on glacial outwash plains. Slopes are mainly plane. The soil has the profile described as representative of the series. Included with it in mapping were small areas of Arvilla and Sioux soils.

Runoff is slow. This soil has a restricted rooting zone and is droughty. Available water is not adequate during part of the growing season in most years. Soil blowing is a hazard, but it can easily be controlled.

This soil is suited to cultivated crops, but it is better suited to pasture. Most of the acreage is used for crops. Droughtiness is the main concern of management. Capability unit IIIs–6; windbreak suitability group 6.

RnB—Renshaw loam, 3 to 6 percent slopes. This soil is gently sloping and is on glacial outwash plains. Slopes are mainly plane and short and convex. Included with this soil in mapping were small areas of Arvilla and Sioux soils.

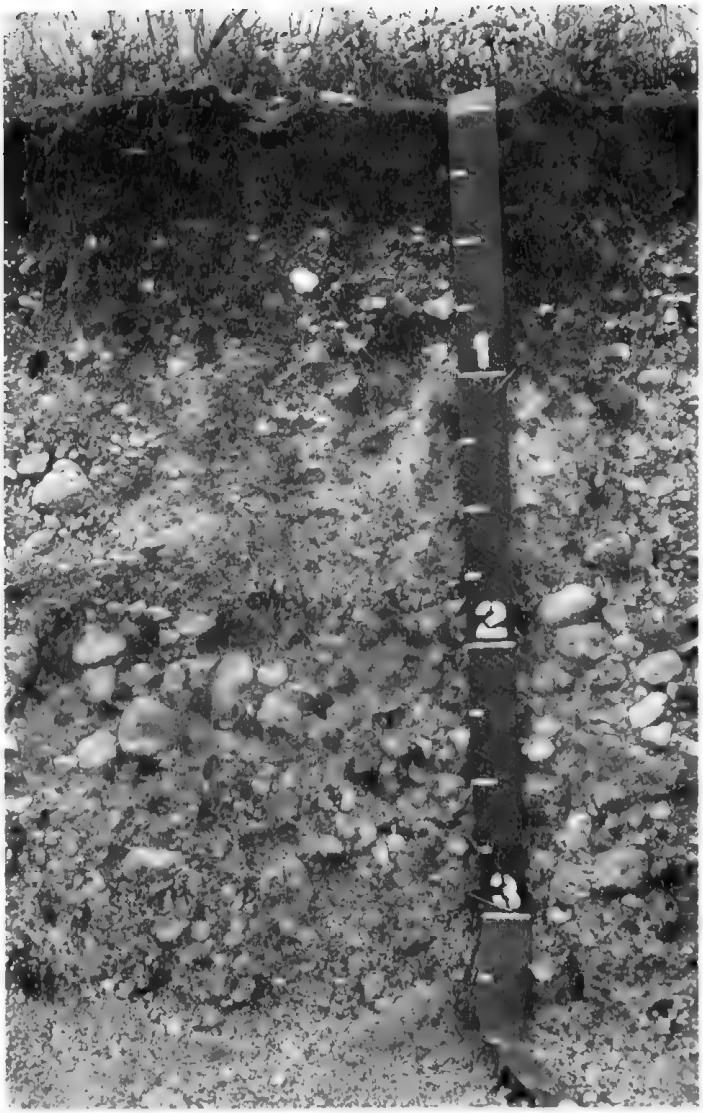
Runoff is medium. This soil has a restricted root zone and is droughty. Available water is not adequate during part of the growing season in most years. Soil blowing is a hazard, but it can be easily controlled. The hazard of water erosion is moderate.

This soil is suited to cultivated crops, but it is better suited to pasture. Most of the acreage is used for crops. Droughtiness and erosion are the main concerns of management. Capability unit IIIe–6; windbreak suitability group 6.

Sioux Series

The Sioux series consists of excessively drained, nearly level to hilly loamy soils. These soils are on smooth and convex areas on glacial outwash plains, ridges, and the sides of valleys. Sand and gravel are at a depth of 10 inches or less.

In a representative profile (fig. 14) the surface layer is very dark gray loam about 5 inches thick. The underlying material, to a depth of 60 inches, is very dark brown, loose loamy coarse sand and gravel in the upper 5 inches, grayish-brown sand and gravel in the middle 10 inches, and dark grayish-brown sand and gravel in the lower 40 inches.



Permeability is very rapid, and the available water capacity is very low. Runoff is slow to medium. The content of organic matter is moderately low, and fertility is low. The root zone is restricted to the upper few inches of the underlying material, which is sand and gravel. These soils are droughty.

Most areas are in native grass used for pasture. These soils are not suited to cultivated crops.

Representative profile of Sioux loam, 1 to 6 percent slopes, 270 feet south and 1,280 feet west of the northeast corner of sec. 31, T. 164 N., R. 84 W., in a cultivated field.

Ap—0 to 5 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) when dry; weak, medium, crumb structure; slightly hard, very friable, nonsticky and slightly plastic; neutral; abrupt, smooth boundary.

IIC1—5 to 10 inches, very dark brown (10YR 2/2) loamy coarse sand and gravel, dark grayish brown (10YR 4/2) when dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; gradual, wavy boundary.

IIC2ca—10 to 20 inches, grayish-brown (10YR 5/2) sand and gravel, white (10YR 8/2) when dry; single grained; loose, nonsticky and nonplastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIC3—20 to 60 inches, dark grayish-brown (10YR 4/2) sand and gravel, light gray (10YR 7/2) when dry; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline.

Thickness of the solum, depth to sand and gravel, and depth to lime range from 4 to 10 inches. The A1 horizon is very dark gray or black. In a few places it is gravelly loam, sandy loam, or gravelly sandy loam. In some places there is a transitional AC horizon. The IIC horizon is grayish brown, light brownish gray, or brown. In areas where there is no IICca horizon, the lower sides and the bottoms of pebbles in the upper part of the IIC horizon are coated with lime.

Sioux soils are near Arvilla and Renshaw soils. They are shallower to sand and gravel than Arvilla and Renshaw soils, and they lack a B2 horizon, which those soils have.

SoB—Sioux loam, 1 to 6 percent slopes. This soil is nearly level in about half the acreage and undulating in the rest. It is on low ridges and plane side slopes on glacial outwash plains. It has the profile described as representative of the series. Included with it in mapping were small areas of Arville sandy loam and Renshaw loam.

Runoff is slow. This soil has a restricted root zone and is droughty. Available water is not adequate during most of the growing season in most years. Soil blowing is a hazard in tilled areas.

This soil is better suited to pasture than to other uses and is used mainly for pasture. It is not suited to cultivated crops. Droughtiness is the main concern of management. Capability unit VIs–6; windbreak suitability group 10.

SoD—Sioux loam, 6 to 20 percent slopes. This soil is mainly hilly, but in places it is gently rolling, rolling, and steep. It is on outwash ridges in the glacial moraines and on slope crests and side slopes along the outer edge of the valleys of the Souris and Des Lacs Rivers. Areas are convex or plane, and relief is 40 to 50 feet in most places.

Runoff is medium. The soil has a restricted root zone and is very droughty. Available water is not adequate during most of the growing season in most years. The hazard of erosion is moderate. Soil blowing is a hazard in tilled areas.

This soil is suited only to pasture and is mainly used for pasture. Droughtiness and erosion are the main concerns of management. Capability unit VIs–6; windbreak suitability group 10.

Svea Series

The Svea series consists of deep, moderately well drained, nearly level to gently sloping, loamy soils. These soils are on plane and concave foot slopes and in swales on glacial till plains. They formed in glacial till and, in places, in alluvium.

In a representative profile the surface layer is black loam about 7 inches thick. The subsoil is very dark brown, friable loam about 12 inches thick. The underlying material, to a depth of 25 inches, is olive-brown loam. Below this, to a depth of 60 inches, it is mottled light olive-brown loam.

Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. The available water capacity is high. These soils receive some runoff from surrounding higher areas, and runoff is slow to medium. The content of organic matter and fertility are high.

Most areas are cultivated. Some narrow channeled areas are in native grass, trees, and shrubs used for pasture and hay. Most areas of these soils are well suited to cultivated crops.

Representative profile of Svea loam, 1 to 3 percent slopes, 2,568 feet east and 255 feet north of the southwest corner of sec. 22, T. 160 N., R. 84 W., in a cultivated field.

Ap—0 to 7 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure; slightly plastic; neutral; abrupt, smooth boundary.

B2—7 to 19 inches, very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) when dry; moderate, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; hard, friable, sticky and plastic; neutral; clear, wavy boundary.

C1ca—19 to 25 inches, olive-brown (2.5Y 4/4) loam, light brownish gray (2.5Y 6/2) when dry; moderate, medium, prismatic structure parting to weak, medium and fine, subangular blocky; hard, friable, sticky and plastic; strong effervescence; moderately alkaline; gradual, wavy boundary.

C2ca—25 to 60 inches, light olive-brown (2.5Y 5/4) loam, light yellowish brown (2.5Y 6/4) when dry; common, medium, distinct, gray (5Y 5/1) mottles, light gray (5Y 6/1) when dry; moderate, medium, subangular blocky structure; hard, friable, sticky and plastic; strong effervescence; moderately alkaline.

Thickness of the solum and, in most places, depth to lime range from 16 to 30 inches. The A horizon is black or very dark gray and ranges from 5 to 12 inches in thickness. The B2 horizon is dark-brown and very dark brown loam and light clay loam. It has weak to moderate, prismatic structure parting to weak to moderate, subangular blocky. Lime is mainly diffuse in the Cca horizon, but in places it occurs as segregated threads and masses. The C horizon is mainly loamy glacial till, but in a few places it is loamy alluvium that has bands of pebbles and is texturally stratified.

Svea soils are near Barnes and Hamlet soils. They are darker colored to a greater depth than both of those soils, and they are not so well drained as Barnes soils.

SvA—Svea loam, 1 to 3 percent slopes. This soil is nearly level and is in swales on glacial till plains. It has plane and slightly concave (fig. 15) slopes. The soil has the profile described as representative of the series.

Runoff is slow. This soil receives runoff from surrounding higher areas. It is susceptible to soil blowing if it is left bare.

Nearly all the acreage is used for crops. The soil is well suited to all crops commonly grown in the county. Controlling soil blowing and maintaining the content of organic matter and fertility are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

SvB—Svea loam, 3 to 6 percent slopes. This soil is gently sloping and is in swales on glacial till plains. It has plane and concave slopes.

Runoff is medium. This soil receives runoff from surrounding higher areas. The hazard of water erosion is moderate, and the soil is susceptible to soil blowing if it is left bare.

Nearly all the acreage is used for crops. The soil is suited to all crops commonly grown in the county. Controlling soil blowing and water erosion and maintaining the content of organic matter and fertility are the main

Figure 15.—**Dark-colored Svea loam in nearly level swales.**

concerns of management. Capability unit IIe–6; windbreak suitability group 1.

SwB—Svea loam, channeled, 1 to 6 percent slopes. This soil is nearly level to gently sloping and is along channeled intermittent drainageways in broad swales and valleys. Most of the acreage is on bottoms of coulees that adjoin the valleys of the Des Lacs and Souris Rivers. The channels are mainly 2 to 5 feet deep and have short, abrupt slopes. Except in the channels, the soils are mainly nearly level. Areas between the channels are small.

Runoff is slow to medium. This soil receives runoff from the surrounding higher areas. The hazard of water erosion is severe in the channels. This soil is susceptible to soil blowing if it is left bare.

Most areas are in native grass, and native trees and shrubs grow in the channels in many places. The soil is used mainly for pasture and hay. It is too cut up by channels to be suited to crops. Capability unit VIe–6; windbreak suitability group 3.

SyA—Svea loam, fans, 1 to 3 percent slopes. This soil is nearly level and is on foot slopes of valleys. It has long, smooth slopes and is at a higher elevation than flood plains along the river. It has a profile similar to the one described as representative of the series, but in many places it has thin sandy strata below the solum.

Runoff is slow. This soil receives runoff from surrounding higher areas. The hazard of soil blowing is slight, but the hazard of water erosion is severe in the channels carrying runoff from the adjacent uplands.

Most areas are cultivated. The soil is well suited to all crops commonly grown in the county. Controlling erosion in the channels and soil blowing and maintaining the content of organic matter and fertility are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

SyB—Svea loam, fans, 3 to 6 percent slopes. This soil is gently sloping and is on valley foot slopes. It has long, plane slopes and is at a higher elevation than flood plains along the river. It has a profile similar to the one described as representative of the series, but in many places it has thin sandy strata below the subsoil.

Runoff is medium. This soil receives runoff from surrounding higher areas. The hazard of soil blowing is slight. The hazard of water erosion is generally moderate, but it is severe in the channels carrying runoff from the adjacent uplands.

Most areas are cultivated. The soil is suited to all crops commonly grown in the county. Controlling erosion and soil blowing and maintaining the content of organic matter and fertility are the main concerns of management. Capability unit IIe–6; windbreak suitability group 1.

Swenoda Series

The Swenoda series consists of deep, moderately well drained, nearly level and undulating soils. These soils are on glacial till plains. They formed in 20 to 40 inches of loamy, wind-reworked glacial outwash and in the underlying glacial till.

In a representative profile the surface layer is black fine sandy loam about 9 inches thick. The subsoil is very friable and about 21 inches thick. It is very dark grayish-brown fine sandy loam in the upper part and dark-brown loam in the lower part. The underlying material is grayish-brown loam glacial till that is gravelly in the upper part.

Permeability is moderately rapid in the upper part of the soil and moderately slow in the lower part. The available water capacity is moderate. Runoff is slow. The content of organic matter is high, and fertility is medium. The hazard of soil blowing is severe.

Most areas are cultivated. These soils are suited to all crops commonly grown in the county.

Representative profile of Swenoda fine sandy loam, 1 to 3 percent slopes, 950 feet east and 90 feet north of the southwest corner of sec. 10, T. 163 N., R. 87 W., in a native pasture.

A1—0 to 9 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, fine, crumb; very friable, nonsticky and nonplastic; neutral; clear, smooth boundary.

B21—9 to 23 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, brown (10YR 5/3) when dry; weak, coarse, prismatic structure; very friable, nonsticky and nonplastic; neutral; gradual, wavy boundary.

IIB22—23 to 30 inches, dark-brown (10YR 4/3) loam, brown (10YR 5/3) when dry; moderate, medium, prismatic structure parting to moderate, medium and fine, angular blocky; very friable, slightly sticky and slightly plastic; mildly alkaline; gradual, wavy boundary.

IIC1—30 to 36 inches, grayish-brown (2.5Y 5/2) gravelly loam, light brownish gray (2.5Y 6/2) when dry; weak, coarse, subangular blocky structure; friable, slightly sticky and nonplastic; slight effervescence; moderately alkaline; gradual boundary.

IIC2—36 to 60 inches, grayish-brown (2.5Y 5/2) loam, light brownish gray and white (2.5Y 6/2 and 8/2) when dry; weak, coarse, subangular blocky structure; friable, sticky and plastic; pockets of gravel; slight effervescence; moderately alkaline.

Thickness of the solum and, in most places, depth to lime range from 20 to 40 inches. The A1 or Ap horizon is black or very dark gray fine sandy loam, very fine sandy loam, or light loam. The B2 horizon is mainly dark grayish-brown, very dark grayish-brown, dark-brown, or brown fine sandy loam or sandy loam, but in places the lower part is loam. The IIC horizon ranges from loam to clay loam. In places there is a thin pebble line at the upper boundary of the IIC horizon. In many places there is a IICca horizon.

Swenoda soils are near Embden soils. They are finer textured below the solum than Embden soils. They have a coarser textured B2 horizon than Svea soils.

SzA—Swenoda fine sandy loam, 1 to 3 percent slopes. This soil is nearly level and is on glacial till plains that have a thin mantle of glacial outwash. It has mainly plane and convex slopes. The soil has a profile similar to the one described as representative of the series, but in places the surface layer is light loam. Included with this soil in mapping were small areas of Barnes loam and Tonka silt loam.

Runoff is slow. This soil is highly susceptible to soil blowing.

Most areas are cultivated. The soil is suited to all crops commonly grown in the county. Controlling soil blowing and maintaining the content of organic matter and fertility are the main concerns of management. Capability unit IIIe-3; windbreak suitability group 5.

SzB—Swenoda fine sandy loam, 3 to 6 percent slopes. This soil is undulating and is on glacial till plains that have a thin mantle of glacial outwash. Areas are mainly smooth or convex. The soil has a profile similar to the one described as representative of the series, but in places the surface layer is light loam. Included with this soil in mapping were small areas of Barnes loam and Tonka silt loam.

Runoff is slow. This soil is slightly susceptible to soil blowing and, in drainageways, is moderately susceptible to gullying.

Most areas are cultivated. The soil is suited to all crops commonly grown in the county. Controlling soil blowing and water erosion and maintaining the content of organic matter and fertility are the main concerns of management. Capability unit IIIe-3; windbreak suitability group 5.

Tiffany Series

The Tiffany series consists of deep, poorly drained, level soils. These soils are in shallow depressions, on flats, and in swales on glacial outwash plains.

In a representative profile the surface layer is black fine sandy loam about 9 inches thick. The next layer is dark grayish-brown very friable sandy loam about 23 inches thick. The underlying material, to a depth of about 60 inches, is mottled light olive-gray very fine sandy loam in the upper part and mottled olive-gray loam till in the lower part.

Permeability and the available water capacity are moderate. Runoff is very slow. The content of organic matter is high, and fertility is medium. The water table is within 3 feet of the surface in spring. These soils are highly susceptible to soil blowing.

Nearly all the areas are cultivated. These soils are suited to all crops commonly grown in the county.

Representative profile of Tiffany fine sandy loam, 1,790 feet west and 165 feet north of the southeast corner of sec. 9, T. 163 N., R. 87 W.

A1—0 to 9 inches, black (10YR 2/1) fine sandy loam, very dark gray (10YR 3/1) when dry; weak, coarse, subangular blocky structure parting to granular; slightly hard, very friable, slightly sticky and nonplastic; neutral; abrupt, smooth boundary.

AC—9 to 32 inches, dark grayish-brown (2.5Y 4/2) sandy loam, light brownish gray (2.5Y 6/2) when dry; few, coarse, distinct, dark yellowish-brown (10YR 4/4) mottles, yellowish brown (10YR 5/6) when dry; weak, fine and medium, subangular blocky structure; soft, very friable, slightly sticky and nonplastic; neutral; clear, wavy boundary.

C1ca—32 to 46 inches, light olive-gray (5Y 6/2) very fine sandy loam, white (5Y 8/2) when dry; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles, olive yellow (2.5Y 6/6) when dry; massive; hard, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; clear, wavy boundary.

IIC2—46 to 60 inches, olive-gray (5Y 5/2) loam till, light gray (5Y 7/1) when dry; common, medium, distinct, light olive-brown (2.5Y 5/6) mottles, olive yellow (2.5Y 6/6) when dry; massive; very hard, firm, sticky and plastic; strong effervescence; moderately alkaline.

Depth to lime is generally 20 to 40 inches, but in a few places it is more than 60 inches. The A1 horizon is very dark gray or dark gray when dry and ranges from 8 to 14 inches in thickness. In most places there is a transitional AC horizon that has a hue of 2.5Y or 5Y, a value of 4 to 6 when moist, and a chroma of

1 or 2. Mottles range from few to many, distinct to prominent from the lower part of the A1 horizon throughout the profile and are more numerous and more distinct with increasing depth. The soil between depths of 10 and 40 inches ranges from sandy loam to light loam and is stratified in places. Finer textured material is at a depth of more than 40 inches in many places.

Tiffany soils are near Embden soils. They are not so well drained as Embden soils and have lime at a greater depth than Wyndmere soils.

Tf—Tiffany fine sandy loam. This soil is level and is in swales and flats in areas of glacial outwash. It occurs as small areas and has plane or slightly concave slopes. Slope is 0 to 1 percent. Included with this soil in mapping were small areas of Wyndmere fine sandy loam.

Runoff is very slow. The soil receives excess water from surrounding higher areas. In most years the water table is 3 to 5 feet below the surface during the growing season and less than 3 feet from the surface in spring. The soil is occasionally flooded and ponded for short periods. It is highly susceptible to soil blowing.

Nearly all the acreage is cultivated. The soil is suited to all crops commonly grown in the county. Wetness and soil blowing are the main concerns of management. Capability unit IIIw-5; windbreak suitability group 2.

Tonka Series

The Tonka series consists of deep, poorly drained, level soils. These soils are in shallow depressions on glacial till plains.

In a representative profile the surface layer is very dark gray silt loam about 7 inches thick. The subsurface layer is grayish-brown silt loam about 7 inches thick. The subsoil is firm clay loam about 22 inches thick. It is very dark gray in the upper part and dark olive gray and mottled in the lower part. The underlying material, to a depth of 60 inches, is mottled olive loam.

Permeability is slow, and the available water capacity is high. The content of organic matter and fertility are high. In most years these soils are ponded during the early part of the growing season.

Most areas are used for crops. These soils are not well suited to cultivated crops unless excess water is removed. Undrained areas are suited to hay and pasture.

Representative profile of Tonka silt loam, 2,058 feet east and 258 feet south of the northwest corner of sec. 29, T. 162 N., R. 87 W., in a native meadow.

A1—0 to 7 inches, very dark gray (10YR 3/1) silt loam, grayish brown (10YR 5/2) when dry; moderate, medium and fine, subangular blocky structure parting to granular; slightly hard, friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

A2—7 to 14 inches, grayish-brown (2.5Y 5/2) silt loam, light gray (2.5Y 7/2) when dry; common, medium, distinct, light olive-brown (2.5Y 5/6) mottles, light yellowish-brown (2.5Y 6/4) when dry; moderate, medium, platy structure; friable, slightly plastic; neutral; clear, irregular boundary.

B2t—14 to 32 inches, very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) when dry; moderate, coarse, prismatic structure parting to moderate, medium and fine, angular blocky; very hard, firm, very sticky and plastic; neutral; clear, wavy boundary.

B3—32 to 36 inches, dark olive-gray (5Y 3/2) clay loam, olive gray (5Y 5/2) when dry; common, medium, distinct, olive (5Y 5/4) mottles, pale olive (5Y 6/4) when dry; weak, coarse, prismatic structure; very hard, firm, very sticky and plastic; slight effervescence; mildly alkaline; clear, wavy boundary.

C1ca—36 to 50 inches, olive (5Y 5/4) loam, pale olive (5Y 6/4) when dry, few, medium, distinct, olive-gray (5Y 5/2) mottles; massive; hard, friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, irregular boundary.

C2—50 to 60 inches, olive (5Y 5/4) loam, pale olive (5Y 6/3) when dry; few, medium, faint, olive-gray (5Y 5/2) mottles, light gray (5Y 7/2) when dry; massive; hard and friable; sticky and plastic; strong effervescence; moderately alkaline.

Depth to lime ranges from 20 to more than 60 inches. There is a wide range in the amount and distinctness of mottles in all horizons below the A1 horizon. The A horizon ranges from 8 to 24 inches in thickness. The A1 horizon is black or very dark gray silt loam, silty clay loam, or loam. The A2 horizon is gray or grayish brown and ranges from 4 to 10 inches in thickness. It tongues into the B2 horizon in many places. The B2 horizon ranges from clay loam to clay. It has weak to strong, prismatic structure parting to moderate to strong, angular blocky. The C horizon is loamy glacial till or, in places, alluvium.

Tonka soils are in positions on the landscape similar to those on which Parnell and Fulda soils occur. They have an A2 horizon, which does not occur in Parnell and Fulda soils.

To—Tonka silt loam. This soil is level and is in shallow depressions on glacial till plains. The slope is 0 to 1 percent. Included with this soil in mapping were small areas of silty clay loam.

This soil is flooded by runoff from adjacent higher areas during spring thaws and heavy rains, and it remains ponded for a few days to several months at a time. In most years the water table is 1 foot to 3 feet below the surface during the later part of the growing season. The hazard of soil blowing is slight in tilled areas.

Most of the acreage is used for crops, but the soil is not well suited to crops unless excess water is removed. In many years, seeding has to be delayed and crops are flooded. Some areas do not have adequate outlets for removal of excess water. Undrained areas are better suited to late-season hay and pasture than to other uses. Wetness is the main concern of management. Capability unit IIw–6; windbreak suitability group 2.

Vallers Series

The Vallers series consists of deep, poorly drained, level soils. These soils are in depressions, on flats, and on the rims of closed depressions on glacial till plains. They contain a moderate to large amount of lime throughout.

In a representative profile the surface layer is very dark gray loam about 9 inches thick. The underlying material, to a depth of 60 inches, is loam glacial till, in the upper part, of which lime has concentrated. In sequence from the top, the upper 5 inches is light gray, the next 9 inches is light olive brown and mottled, the next 12 inches is gray and olive and mottled, and the lower 25 inches is gray and mottled.

Permeability is moderately slow, and the available water capacity is high. Runoff is slow. The content of organic matter is moderate, and fertility is high. In most years these soils have a high water table during the growing season and, in a few years, are ponded for short periods. They are highly susceptible to soil blowing.

Most areas are cultivated. These soils are suited to all crops commonly grown in the county, but wetness interferes with seeding in most years.

Representative profile of Vallers loam, 820 feet west and 140 feet south of the northeast corner of sec. 8, T. 162 N., R. 87 W., in a cultivated field.

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) when dry; moderate, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; strong effervescence; moderately alkaline; abrupt, smooth boundary.

A12—6 to 9 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to moderate, medium, crumb; hard, friable, sticky and plastic; few light-gray (10YR 7/1) threads of lime; strong effervescence; moderately alkaline; clear, wavy boundary.

C1gca—9 to 14 inches, light-gray (10YR 6/1) loam, light gray (10YR 6/1 and 7/1) when dry; weak, coarse, subangular blocky structure; slightly hard, friable, sticky and plastic; tongues of material from the A1 horizon; lime completely diffused throughout; violent effervescence; moderately alkaline; clear, wavy boundary.

C2gca—14 to 23 inches, light olive-brown (2.5Y 5/4) loam, light brownish gray (2.5Y 6/2) when dry; many, large, prominent, olive-yellow (2.5Y 6/6) mottles; massive; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

C3g—23 to 35 inches, gray and olive-brown (5Y 5/1 and 2.5Y 4/4) loam, light brownish gray (2.5Y 6/2) when dry; many, large, prominent, olive-yellow (2.5Y 6/6) mottles; massive; hard, friable, sticky and plastic; many large nests of gypsum; strong effervescence; moderately alkaline; gradual, wavy boundary.

C4g—35 to 60 inches, gray (5Y 5/1) loam, light brownish gray (2.5Y 6/2) when dry; many, large, prominent, dark yellowish-brown (10YR 4/4) mottles, light olive brown (2.5Y 5/6) when dry; massive; very hard, firm, sticky and plastic; few nests of gypsum; slight effervescence; moderately alkaline.

The A1 horizon is very dark gray or black and ranges from 5 to 12 inches in thickness. In a few places it lacks free lime. The C horizon is loam or light clay loam. It contains pockets of gypsum in many places. Mottles in the C horizon range from few to many, faint to prominent, and fine to large but in places are lacking in the upper part.

Vallers soils are near Hamerly and Tonka soils. They are more poorly drained than Hamerly soils. They contain much more lime than Tonka soils, lack a B2 horizon, and have less clay and more sand in the solum than those soils.

Va—Vallers loam. This soil is level and is around large depressions and in flats of low-lying till plains. It has plane or slightly concave slopes. The slope is 0 to 1 percent. A few small areas of saline soils are indicated on the detailed soil map by a special spot symbol.

Runoff is slow. In a few years this soil is ponded for short periods. In most years the water table is 1 foot to 3 feet below the surface during the growing season. Bare areas are very susceptible to soil blowing.

Most of the acreage is used for late-seeded small grain and tame hay. In most years spring seeding has to be delayed because of wetness. The soil is suited to all crops commonly grown in the county if excess water is removed. Wetness and soil blowing are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Velva Series

The Velva series consists of deep, well-drained, level to gently sloping, loamy soils that formed in alluvium. These soils are on bottom lands of the Souris and Des Lacs Rivers (fig. 16).

In a representative profile the surface layer is very dark brown loam about 8 inches thick. The subsoil is very dark grayish-brown, very friable silt loam about 11 inches thick. The underlying material, to a depth of 60 inches, is mottled dark grayish-brown very fine sandy loam.

Permeability is moderate, and the available water capacity is high. Runoff is slow. The content of organic matter is moderate, and fertility is high. These soils are subject to flooding and are susceptible to soil blowing.

Most areas are cultivated. Some are in native trees and shrubs or in grass used for pasture and hay. Most areas are suited to cultivated crops.

Representative profile of Velva loam, 160 feet south and 15 feet west of the northeast corner of sec. 22, T. 163 N., R. 87 W., in native grass.

A1—0 to 8 inches, very dark brown (10YR 2/2) loam, dark gray (10YR 4/1) when dry; crumb structure; soft, very friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

B2—8 to 19 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, medium and fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; slight effervescence; mildly alkaline; clear, wavy boundary.

C1—19 to 27 inches, dark grayish-brown (2.5Y 4/2) very fine sandy loam, grayish brown (2.5Y 5/2) when dry; few, fine, faint, olive-brown (2.5Y 4/4) mottles, light olive brown (2.5Y 5/6) when dry; moderate, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; slightly hard, very friable, nonsticky and slightly plastic; strong effervescence; mildly alkaline; gradual, wavy boundary.

C2—27 to 60 inches, dark grayish-brown (2.5Y 4/2) very fine sandy loam, light brownish gray (2.5Y 6/2) when dry; few, fine, faint, dark yellowish-brown (10YR 4/4) mottles, yellowish brown (10YR 5/6) when dry; massive; stratified; slightly hard, very friable, nonsticky and slightly plastic; strong effervescence; mildly alkaline.

One or more buried A horizon occurs in many places. Sandy strata are at a depth of more than 40 inches in places. The A1 horizon is very dark brown, very dark grayish-brown, or very dark gray loam, silt loam, or very fine sandy loam. In places it contains lime.

Velva soils are near LaDelle and Ludden soils. They are better drained and contain less clay and more sand to a depth through 40 inches than those soils.

Vb—Velva loam. This soil is level and is on bottom lands along the Souris and Des Lacs Rivers. It has slopes of 0 to 1 percent. This soil has the profile described as representative of the series.

Runoff is slow. This soil is flooded for a few days in spring in some years. Cultivated areas are subject to soil blowing.

Most of the acreage is used for crops. Areas in native grass, trees, and shrubs are used mainly for pasture. Some areas that are free of trees and shrubs are used for hay. The soil is suited to all crops commonly grown in the county. Flooding and soil blowing are the main concerns of management. The flooding is mainly beneficial to alfalfa and grass. Capability unit IIe–5; windbreak suitability group 1.

Vd—Velva loam, channeled. This soil is level to gently sloping and is next to the meandering stream channel on bottom lands along the Des Lacs River. It has slopes of 0 to 6 percent. This soil is mainly nearly level, but in the

Figure 16.—**Area of bottom lands along the Souris River. The soils are Velva loam, LaDelle silty clay loam, and Ludden silty clay.**

channels it is gently sloping. At the channel edge, this soil has short and abrupt slopes. The soil has somewhat irregular relief, and in places there are swales and low ridges that remain after the stream channel changes.

Runoff is slow. This soil is flooded for a few days in spring in some years.

Nearly all the acreage is in native grass and patches of trees and shrubs used for pasture. The flooding is beneficial to the native vegetation. Some areas that are free of trees and shrubs are used for hay. The soil is too cut up by channels to be suited to cultivation. Capability unit VIe–6; windbreak suitability group 1.

Williams Series

The Williams series consists of deep, well-drained, nearly level and undulating loamy soils. These soils are on glacial till plains.

In a representative profile the surface layer is very dark brown loam about 4 inches thick. The subsoil is dark-brown friable loam about 11 inches thick. The underlying material, to a depth of about 60 inches is light olive-brown and olive-brown loam till, in the upper part of which lime has accumulated.

Permeability is moderate in the subsoil and moderately slow in the underlying material. The available water capacity is high. Runoff is slow to moderate. The content of organic matter is moderate, and fertility is high. The soils are slightly susceptible to soil blowing and slightly to moderately susceptible to water erosion.

559-010—77——3

Nearly all the acreage is cultivated. These soils are well suited to all crops commonly grown in the county.

Representative profile of Williams loam, 1 to 3 percent slopes, 1,600 feet north and 525 feet east of the southwest corner of sec. 32, T. 158 N., R. 86 W., in a native pasture.

A1—0 to 4 inches, very dark brown (10YR 2/2) loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to strong, fine, crumb; slightly hard, friable, sticky and plastic; neutral; clear, wavy boundary.

B2t—4 to 15 inches, dark-brown (10YR 4/3) loam, brown (10YR 5/3) when dry; strong, medium, prismatic structure parting to strong, medium, angular blocky; hard, friable, sticky and plastic; thin dark-brown (10YR 3/3) clay films on all faces of peds, brown (10YR 4/3) when dry; mildly alkaline; clear, wavy boundary.

C1ca—15 to 24 inches, light olive-brown (2.5Y 5/4) loam, light brownish gray (2.5Y 6/2) when dry; weak, medium, prismatic structure parting to weak, medium, subangular blocky; hard, friable, sticky and plastic; many white masses of lime; violent effervescence; moderately alkaline; gradual, wavy boundary.

C2ca—24 to 36 inches, light olive-brown (2.5Y 5/4) loam, light brownish gray (2.5Y 6/2) when dry; massive; hard, friable, sticky and plastic; common white masses of lime; violent effervescence; moderately alkaline; gradual, wavy boundary.

C3—36 to 60 inches, olive-brown (2.5Y 4/4) loam, light yellowish brown (2.5Y 6/4) when dry; massive; hard, friable, sticky and plastic; strong effervescence; moderately alkaline.

Depth to lime and, in most places, thickness of the solum range from 12 to 18 inches. The B2t horizon is dark-brown, dark grayish-brown, or very dark grayish-brown loam or clay

loam and 5 to 14 inches thick. It has strong, medium or coarse, prismatic structure parting to strong, fine or medium, angular blocky. The Cca horizon has diffuse lime and few to many soft masses of lime.

Williams soils are near Max and Zahl soils. They have a B2t horizon, which is lacking in Max and Zahl soils, and they have a thicker solum than Zahl soils.

WmA—Williams loam, 1 to 3 percent slopes. This soil is nearly level and is on smooth till plains. It has the profile described as representative of the series. Included with it in mapping were a few small areas of deep, dark-colored soils in swales and a few depressions in which Tonka silt loam occurs.

Runoff is slow. Soil blowing is a slight hazard, but it is easily controlled.

Nearly all the acreage is cultivated. The soil is well suited to all crops commonly grown in the county. The main concern of management is maintaining the content of organic matter and fertility. Capability unit IIc–6; windbreak suitability group 3.

WmB—Williams loam, 3 to 6 percent slopes. This soil is undulating and is on smooth till plains. Included with it in mapping were a few small areas of Tonka soils in basins and a few areas where slopes are more than 6 percent.

Runoff is medium. Water erosion is a moderate hazard, and soil blowing is a slight hazard.

Most areas are cultivated. The soil is well suited to all crops commonly grown in the county. The main concerns of management are controlling erosion and maintaining the content of organic matter and fertility. Capability unit IIe–6; windbreak suitability group 3.

Wyndmere Series

The Wyndmere series consists of deep, somewhat poorly drained, nearly level soils. These soils are in slightly depressed basins. They formed in glacial outwash.

In a representative profile the surface layer is black fine sandy loam about 9 inches thick. The underlying material, to a depth of about 44 inches, is grayish-brown fine sandy loam and loamy fine sand that is mottled and in the upper part of which lime has accumulated. Below this, to a depth of 60 inches, it is mottled gray very fine sandy loam.

Permeability is moderately rapid, and the available water capacity is moderate. Runoff is slow. The content of organic matter is high, and fertility is medium. In spring, the water table is near the surface. These soils are highly susceptible to soil blowing.

Most areas are used for crops. These soils are suited to all crops commonly grown in the county.

Representative profile of Wyndmere fine sandy loam, 1 to 3 percent slopes, 1,720 feet west and 210 feet south of the northeast corner of sec. 27, T. 163 N., R. 84 W., in a cultivated field.

Ap—0 to 9 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak, fine, crumb structure; soft, very friable, nonsticky and nonplastic; slight effervescence; mildly alkaline; clear, smooth boundary.

C1ca—9 to 26 inches, grayish-brown (2.5Y 5/2) fine sandy loam, light brownish gray (2.5Y 6/2) when dry; few, small, faint, dark yellowish-brown (10YR 4/4) mottles; weak, coarse, prismatic structure; soft, very friable, nonsticky and nonplastic; strong effervescence; moderately alkaline; gradual, wavy boundary.

C2—26 to 44 inches, grayish-brown (2.5Y 5/2) loamy fine sand, light brownish gray (2.5Y 6/2) when dry; weak, fine, subangular blocky structure; soft, very friable, nonsticky and nonplastic; slight effervescence; mildly alkaline; clear, wavy boundary.

IIC3—44 to 60 inches, gray (5Y 5/1) very fine sandy loam, light brownish gray and light yellowish brown (2.5Y 6/2 and 6/4) when dry; many, medium, prominent, dark yellowish-brown (10YR 4/4) mottles; massive; friable, slightly sticky and slightly plastic; slight effervescence; mildly alkaline.

The A1 horizon is black or very dark gray and ranges from 7 to 12 inches in thickness. In places there is an A12ca horizon. The Cca horizon is grayish brown or gray and, in most places, is mottled. Mottles below the Cca horizon range from few to many and faint to prominent. Fine- or coarse-textured material is at a depth of more than 40 inches in places.

Wyndmere soils are near Arveson and Tiffany soils. They are better drained than Arveson soils and are shallower to an accumulation of lime than Tiffany soils.

WyA—Wyndmere fine sandy loam, 1 to 3 percent slopes. This soil is nearly level and is in slightly depressed basins. Included with this soil in mapping were small areas of Arveson soils.

Runoff is slow. In most years the water table is 3 to 5 feet below the surface during the growing season, but is nearer the surface and is ponded for short periods during unusually wet seasons. This soil is highly susceptible to soil blowing. Spring seeding is delayed by wetness in most years.

Most areas are cultivated. The soil is suited to all crops commonly grown in the county. Wetness and soil blowing are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 1.

Zahl Series

The Zahl series consists of deep, well-drained, rolling to very steep soils that have a thin combined surface layer and subsoil. These soils are on slopes and crests of valley breaks and narrow drainage divides. They formed in glacial till. They have convex or plane slopes.

In a representative profile (fig. 17) the surface layer is very dark brown loam about 5 inches thick. The underlying material, to a depth of 13 inches, is very dark grayish-brown loam that has concentrated lime. Below this, to a depth of 60 inches, it is dark grayish-brown loam, in the upper part of which lime has accumulated.

Permeability is moderate in the surface layer and moderately slow in the underlying material. The available water capacity is high. Runoff is rapid. The content of organic matter is moderately low, and fertility is medium. These soils are susceptible to water erosion.

Nearly all the areas are in native grass used for pasture. These soils are too steep to be suited to cultivated crops. They are better suited to pasture than to other uses.

Representative profile of Zahl loam, in an area of Zahl-Max loams, 9 to 15 percent slopes, 1,800 feet north and 300 feet east of the southwest corner of sec. 34, T. 162 N., R. 86 W., in native grass.

A1—0 to 5 inches, very dark brown (10YR 2/2) loam, dark gray (10YR 4/1) when dry; moderate, medium, crumb structure; slightly hard, very friable, slightly sticky and slightly plastic; strong effervescence; mildly alkaline; clear, wavy boundary.

Figure 17.—**Profile of Zahl loam.**

C1ca—5 to 13 inches, very dark grayish-brown (2.5Y 3/2) loam, grayish brown (2.5Y 5/2) when dry; weak, medium, subangular blocky structure; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

C2—13 to 60 inches, dark grayish-brown (2.5Y 4/2) loam, light brownish gray (2.5Y 6/2) when dry; massive; hard, friable, sticky and plastic; violent effervescence to a depth of 21 inches, strong effervescence below; moderately alkaline.

The A1 horizon is very dark gray or very dark brown and ranges from 4 to 7 inches in thickness. The Cca horizon has few to many soft masses of lime. There are thin crustings of lime on the bottom of the pebbles in this horizon. The Cca horizon has very weak, prismatic structure that ranges to weak to moderate, blocky. The C horizon is massive and has horizontal separation (laminar) that, with pressure, parts to blocky fragments.

Zahl soils are near Williams and Max soils. They have a thinner solum than Williams and Max soils, and they lack a B2 horizon, which those soils have. They have a browner A horizon than Buse soils.

ZaD—Zahl-Max loams, 9 to 15 percent slopes. The soils making up this complex are rolling and are in valley breaks and narrow drainage divides. About 45 percent of the complex is Zahl loam, 40 percent is Max loam, and 15 percent is included areas of Svea loam. The Zahl soil is on upper side slopes and crests of breaks, the Max soil is on midslopes and broad ridgetops, and the included Svea soil is in swales. The Zahl and Max soils have the profiles described as representative of their series. The Zahl soil is shallower to underlying material than the Max and Svea soils. The Max soil is not so dark colored to so great a depth as the Svea soil.

Runoff is rapid. The hazard of water erosion is severe in cultivated areas.

Most areas of this complex are used for native pasture. These soils are too steep and too erodible to be suited to crops. Capability unit VIe–5; Zahl soil in windbreak suitability group 8; Max soil in windbreak suitability group 3.

ZaF—Zahl-Max loams, 15 to 60 percent slopes. The soils making up this complex are hilly to very steep and are in valley breaks and narrow drainage divides (fig. 18). Relief ranges from 50 to 200 feet. About 50 percent of the complex is Zahl loam, 40 percent is Max loam, and 10 percent is included areas of Svea loam. The Zahl soil is on upper side slopes and crests of breaks, the Max soil is on midslopes and broad ridgetops, and the included Svea soil is in swales.

The hazard of gullying is severe on cattle trails and in drainageways.

All the acreage is in native grass except for small patches of native trees and shrubs that grow in some drainageways. The soils are used for pasture. They are too steep and too erodible to be suited to crops and hay. Capability unit VIe–5; Zahl soil in windbreak suitability group 8; Max soil in windbreak suitability group 3.

Use and Management of the Soils

In the following pages the management of soils in Renville County for crops is discussed, the system of capability grouping used by the Soil Conservation Service is explained, and the management of soils in the county is discussed by capability units. Predicted yields of principal crops are given. Also discussed is the management of soils for woodland and windbreaks and for wildlife. The limitations that affect recreational uses of the soils and the properties and features that affect engineering uses are listed, mainly in tables.

Areas of native range in this county are small. Grazing should be regulated so that about half of the annual growth of desirable plants is consumed. Deferring grazing helps to maintain and improve range condition. Proper location of salt and water improves the distribution of grazing.

General Management of Cropland [2]

About 85 percent of Renville County is cultivated. Spring wheat is the principal crop, but flax and barley are also important crops. The main considerations in

[2] By Edward R. Weimer, agronomist, Soil Conservation Service

Figure 18.—**Drainageway leading to bottom lands along the Souris River. The soils are Zahl-Max loams, 15 to 60 percent slopes.**

managing cultivated soils in Renville County are conserving moisture, controlling soil blowing, and maintaining fertility. Drainage and removal of stones are also needed in places.

In dryfarmed areas conserving moisture generally means reducing evaporation, limiting runoff, increasing infiltration, and controlling weeds. Stubble mulching, contour farming, stripcropping, field windbreaks, buffer strips, timely tillage, minimum tillage, use of crop residue, and application of fertilizer are beneficial. Fallow helps to control weeds and build up the moisture content.

Among the measures that help to control erosion are cover crops, stripcropping, buffer strips, windbreaks, contour farming, diversions, waterways, minimum tillage, timely tillage, emergency tillage, and use of crop residue. Generally, a combination of several measures is used.

Among the measures that help to maintain fertility are the application of chemical fertilizer, green manure, and barnyard manure and the inclusion in the cropping system of cover crops, grasses, and legumes, as well as the use of summer fallow. Control of erosion also helps to conserve fertility.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These groups are described in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I to VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use. (None in Renville County.)

Class II soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and restrict their use largely to pasture, or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, although they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol; for example, IIe–5 or IIIw–6. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages each of the capability units in Renville County is described, and suggestions for the use and management of the soils in each unit are given. The units are not numbered consecutively, because not all of the units in the Statewide system are represented in this county. To find the capability classification of each individual soil, refer to the "Guide to Mapping Units."

CAPABILITY UNIT IIe–5

Only Velva loam is in this unit. It is a deep, level, well-drained soil that has a surface layer of loam and subsoil of silt loam.

Permeability is moderate, and the available water capacity is high. The content of organic matter is moderate and the fertility is high. Soil blowing is a moderate hazard in cultivated areas, but it can be controlled by stubble mulching and using crop residue. In some areas grassed waterways are needed to control water erosion.

This soil is well suited to all locally grown crops. Many areas are used for tame grass and alfalfa. Fertilizer is beneficial to all crops.

CAPABILITY UNIT IIe–6

This unit consists of deep soils of the Barnes, Hamerly, Hamlet, Svea, Tonka, and Williams series. The surface layer and subsoil are generally loam, but in some of the Barnes soils, they are cobbly loam or gravelly loam; and in the Tonka soil the surface layer is silt loam and the subsoil is clay loam. The slope is 1 to 6 percent. The Barnes and Williams soils are well drained; the Hamerly, Hamlet, and Svea soils are moderately well drained; and the Tonka soil is poorly drained.

All the soils in this unit have high available water capacity and high fertility. Permeability is moderately slow in the Hamerly soil; slow in the Tonka soil; moderate in the subsoil and slow in the underlying material of the Hamlet soil; and moderate in the subsoil and moderately slow in the underlying material of the Barnes, Svea, and Williams soils. The content of organic matter is moderate in the Barnes, Hamerly, and Williams soils and high in the Hamlet, Svea, and Tonka soils. Soil blowing is a moderate hazard (fig. 19).

The soils in this unit are suited to all locally grown crops.

In many years tilling and seeding of the Hamerly and Tonka soils is delayed in spring because of wetness and ponding. Where feasible, drainage of potholes in the Tonka soil facilitates farming operations. On Barnes cobbly loam, tilling is difficult and hard on farm machinery. Using crop residue and stubble mulching provide good control of erosion. Stripcropping and windbreaks are also beneficial. Grassed waterways are necessary in a few areas (fig. 20) to help control erosion. Fertilizer is beneficial to small grain and other crops.

CAPABILITY UNIT IIe–4L

This unit consists of deep, level soils of the Hamerly and Tonka series. The Hamerly soils are limy at or near the surface and have a surface layer and subsoil of loam. They are moderately well drained. The Tonka soil has a surface layer of silt loam and a subsoil of clay loam. It is poorly drained.

All the soils in this unit have high available water capacity and high fertility. Permeability is moderately slow in the Hamerly soils and slow in the Tonka soil. The content of organic matter is moderate in the Hamerly soils and high in the Tonka soil. The Hamerly soil has a seasonal high water table, and consequently has an accumulation of lime. Because the lime causes granulation of the surface layer, this soil is highly susceptible to soil blowing. The Tonka soil is seasonally ponded, and consequently tilling and seeding have to be delayed.

The soils in this unit are suited to all locally grown crops.

Drainage of potholes, where feasible in the Tonka soil, facilitates farming operations. Careful management of crop residue is needed to control soil blowing. Stripcrop-

Figure 19.—Soil blowing on a large field.

Figure 20.—An area where a grassed waterway is needed to reduce erosion and siltation

ping, windbreaks, cover crops, and buffer strips also help to control erosion. The response of crops to applications of fertilizer, mainly phosphate, is good.

CAPABILITY UNIT IIw-4

This unit consists of deep, level, poorly drained soils of the Fargo and Ludden series. The surface layer and subsoil are silty clay.

Permeability is slow, and the available water capacity is high. The fertility is high. The content of organic matter is high in the Fargo soil and moderate in the Ludden soil. Soil blowing is a severe hazard. Because Fargo soil is in broad, flat lake basins of the uplands, during years of excess spring runoff, it is ponded and may remain that way for several years. Drainage is seldom feasible. Because the Ludden soil is in the lowest areas on flood plains along the river, in some years, it is ponded for extended periods of time.

These soils are difficult to work because they are very sticky when wet and hard when dry. The proper timing of spring tillage is important. Cultivating these soils when they are too wet or too dry results in a poor seedbed. The soils are best suited to late-planted crops, such as flax and barley. The surface should be left rough after fall tillage. The response of crops to applications of fertilizer is good.

CAPABILITY UNIT IIw-4L

This unit consists of deep, level, poorly drained soils of the Colvin and Vallers soils. The Colvin soil has a surface layer of silt loam and a subsoil of silty clay loam. The Vallers soil has a surface layer and subsoil of loam.

Both soils in this unit have moderately slow permeability, high available water capacity, and high fertility. The content of organic matter is high in the Colvin soil and moderate in the Vallers soil. These soils are limy at the surface and, consequently, are highly susceptible to soil blowing. They have a seasonal high water table and are intermittently flooded.

If drained, the soils are well suited to small grain. If not drained, they are better suited to late-planted crops, such as barley and flax, than to others. Some areas that remain too wet are used for native hay.

Intensive management of crop residue is needed to control soil blowing.

CAPABILITY UNIT IIw-6

Only Tonka silt loam is in this unit. It is a deep, level, poorly drained soil in shallow depressions. It has a surface layer of silt loam and a subsoil of clay loam.

Permeability is slow, and the available water capacity is high. The content of organic matter and the fertility are high.

This soil is suited to small grain, flax, grass, and legumes. Few areas are in range.

Areas of this soil are farmed along with surrounding soils that are used for crops. Many areas are artificially drained. Even in drained areas tilling often has to be delayed because of excessive wetness.

CAPABILITY UNIT IIc-6

This unit consists of deep, nearly level soils of the Barnes, Great Bend, Hamerly, Hamlet, LaDelle, Svea, Tonka, and Williams series. Most of the soils are loam throughout, but the Great Bend and LaDelle soils have a surface layer and subsoil of silty clay loam, and the Tonka soils have a surface layer of silt loam and a subsoil of clay loam. The Barnes, Great Bend, and Williams soils are well drained; the Tonka soils are poorly drained; and all the other soils are moderately well drained.

All the soils in this unit have high available water capacity. The content of organic matter is moderate to high, and the fertility is high. Permeability is moderately slow in the Hamerly soil, moderate in the Great Bend and LaDelle soils, moderate in the subsoil and slow in the underlying material of the Hamlet soils, and moderate in the subsoil and moderately slow in the underlying material of the Barnes, Svea, and Williams soils. The hazards of soil blowing and water erosion are only slight.

The soils in this unit are well suited to all locally grown crops.

Lack of available moisture is the main limitation. In cultivated areas stubble mulching, using crop residue, and applying commercial fertilizer are needed. Drainage of the depressions in Tonka soils facilitates farming operations.

CAPABILITY UNIT IIIe-3

This unit consists of deep soils of the Embden, Swenoda, Tiffany, and Wyndmere series. The surface layer is fine sandy loam, and the subsoil is sandy loam or fine sandy loam. The slope is 1 to 6 percent. The Embden and Swenoda soils are moderately well drained, the Wyndmere soil is somewhat poorly drained, and the Tiffany soil is poorly drained.

Permeability is moderate to moderately rapid, and the available water capacity is moderate. The content of organic matter is high, and fertility is medium. Soil blowing is a serious hazard. These soils warm up rapidly in spring and are the first soils in the county to be ready for seeding. The use of early maturing crops lessens the risk of damage from drought. In some years tilling the Tiffany and Wyndmere soils has to be delayed because of a seasonal high water table.

The soils in this unit are suited to all locally grown crops. Flax produces only a small amount of residue and is easily damaged by windblown sand. Rye provides good protection from erosion.

A combination of practices is required to control erosion. Using crop residue, stubble mulching, and either stripcropping or patterned windbreak plantings are needed to control soil blowing. Including cover crops, buffer strips, and grass in the cropping system also helps to control soil blowing. In a few places emergency tillage to roughen the surface is needed to control soil blowing. Summer fallow should be used only to control weeds because the amount of moisture that can be stored in the soil is limited. Generally, tillage should be kept to the minimum needed to control weeds and to prepare a seedbed. The application of fertilizer needs to be closely governed by the moisture content at the time of seeding.

CAPABILITY UNIT IIIe-6

This unit consists of soils in the Barnes and Renshaw series. The Barnes soil is a deep, well-drained soil that has a surface layer and subsoil of loam. The Renshaw soil is a somewhat excessively drained soil that has a surface layer and subsoil of loam and is underlain by gravel and sand

at a depth of 10 to 20 inches. The Barnes soil has slopes of 6 to 9 percent, and the Renshaw soil 3 to 6 percent.

Both soils in this unit have a moderate content of organic matter. Permeability is moderately slow in the Barnes soil and moderate in the subsoil and very rapid below the subsoil in the Renshaw soil. The available water capacity is high in the Barnes soil and moderate in the Renshaw soil. The fertility is high in the Barnes soil and medium in the Renshaw soil. The hazards of soil blowing and water erosion are moderate.

The soils in this unit are suited to all locally grown crops. The Renshaw soil is droughty and better suited to early maturing crops than to others.

Good use of crop residue is necessary to control soil blowing and water erosion. The amount of residue is not adequate for protection of fallowed soils, and stripcropping or the use of windbreaks, cover crops, or buffer strips is essential. The Barnes soil should be tilled on the contour. Grassed waterways are needed in places where water accumulates. Including grass and legumes in the cropping system also helps to control erosion.

CAPABILITY UNIT IIIes-3

This unit consists of soils of the Arvilla and Sioux series. The Arvilla soils are somewhat excessively drained soils that have a surface layer and subsoil of sandy loam and are underlain by sand and gravel at a depth of 10 to 20 inches. The Sioux soils are excessively drained soils that have a surface layer of sandy loam or loam and a subsoil of coarse sand and gravel at a depth of less than 10 inches.

These soils have a moderately low content of organic matter and low fertility. Permeability is moderately rapid in the surface layer and subsoil and very rapid below the subsoil in the Arvilla soils, and it is very rapid in the Sioux soils. The available water capacity is low in the Arvilla soils and very low in the Sioux soils. These soils are droughty, and soil blowing is a serious hazard.

The soils are easily worked, but a combination of practices is needed to control soil blowing. Narrow stripcropping and the use of crop residue are essential. It is necessary to include grass in the cropping system every 4 or 5 years or to grow it in permanent buffer strips. Tree windbreaks also help to control erosion, but the number of suitable trees is limited and the height to which the trees can grow at maturity is also limited. Only early maturing crops should be seeded.

CAPABILITY UNIT IIIw-5

This unit consists of deep, level, poorly drained soils of the Arveson and Tiffany series. The Arveson soil has a surface layer of loam and a subsoil of sandy loam, and the Tiffany soil has a surface layer and subsoil of fine sandy loam.

Both soils in this unit have moderate available water capacity and medium fertility. Permeability is moderately rapid in the Arveson soil and moderate in the Tiffany soil. The content of organic matter is moderate in the Arveson soil and high in the Tiffany soil. In cultivated areas the hazard of soil blowing is moderate. The soils have an intermittent high water table.

The soils in this unit are suited to most of the crops commonly grown in the county. Some areas need artificial drainage if crops are to be grown. Stubble mulching and using crop residue are the main practices used to control soil blowing. Stripcropping and windbreaks are alternative measures.

CAPABILITY UNIT IIIw-6

This unit consists of deep, level, poorly drained and very poorly drained soils of the Fulda and Parnell series. The surface layer is silty clay loam, and the subsoil is silty clay.

Permeability is slow, and the available water capacity is high. The content of organic matter and the fertility are high. These soils are not easily eroded. They are frequently ponded for extended periods of time.

If not drained, the soils in this unit are well suited only to water-tolerant grasses, but if drained, they are well suited to grasses, legumes, small grain, and flax.

Grasses and legumes are needed in the crop rotation to use up excess moisture and to maintain permeability and tilth. Sweetclover seeded with small grain or flax is also beneficial.

Summer fallow should be used as little as possible. Fall plowing of drained areas reduces the amount of snow trapped and allows the soil to warm up more rapidly in spring. Hay should be mowed early to allow time for some regrowth before the ground freezes. After mowing, there should be several inches of stubble in the field.

CAPABILITY UNIT IIIs-4L

Only Divide loam, loamy substratum, 1 to 3 percent slopes, is in this unit. It is a somewhat poorly drained, limy soil that is underlain by sand and gravel at a depth of 20 to 36 inches. The surface layer is loam, and the subsoil is gravelly loam.

Permeability is moderate through the subsoil and very rapid below the subsoil. The available water capacity is low to moderate. The content of organic matter is moderate, and the fertility is medium. This soil becomes droughty after the high water table recedes, usually in midsummer. Because it has a limy surface layer, this soil is susceptible to soil blowing.

This soil is used for all the locally grown crops. Barley, rye, and flax are better suited than other crops.

Careful management of crop residue is needed to control erosion. Stripcropping and windbreaks are also needed because, in some years, the amount of residue is not adequate to protect the soil. Including grass in the crop rotation helps to control erosion. Summer fallow should be used only when needed to control weeds, and fallowed soil should be protected with buffer strips. The response of plants to applications of phosphate is good.

CAPABILITY UNIT IIIs-6

Only Renshaw loam, 1 to 3 percent slopes, is in this unit. It is somewhat excessively drained. It has a surface layer and subsoil of loam and is underlain by gravel and sand at a depth of 10 to 20 inches.

Permeability is moderate through the subsoil and very rapid below the subsoil, and the available water capacity is moderate. The content of organic matter is moderate, and the fertility is medium. Soil blowing is a moderate hazard in cultivated areas. The soil is droughty because it has limited space for storage of moisture.

This soil is suited to grass, legumes, and all locally grown crops.

Stripcropping is needed to control soil blowing because the amount of crop residue is so small in dry years. Summer fallow does little good because the soil has limited capacity for storage of moisture. Early maturing crops are better suited than others. Including grass and legumes in the crop rotation improves moisture relationships.

CAPABILITY UNIT IIIs-6P

Only Barnes-Cresbard loams, 1 to 3 percent slopes, are in this unit. Both soils are deep and have a surface layer of loam. The Barnes soil has a subsoil of loam, and the Cresbard soil has a subsoil of clay loam that is a weak claypan and it commonly has salts in the underlying material. The Barnes soil is well drained, and the Cresbard soil is moderately well drained.

Permeability is moderately slow, and the available water capacity is high. The content of organic matter is moderate, and the fertility is high. The claypan and salts in the Cresbard soil restrict the development of roots and use of moisture in the subsoil and underlying material. The crops are stunted and the stands sparse in many areas, particularly where the moisture supply in the soil is critical.

The soils in this unit are better suited to early maturing crops than to others.

Soil blowing is easily controlled by stubble mulching and using crop residue. Applying manure and commercial fertilizer helps to improve tilth and the growth of crops.

CAPABILITY UNIT IVe-2

This unit consists of deep, moderately well drained soils of the Hecla and Lohnes series. The surface layer and subsoil are loamy sand.

Permeability is rapid, and the available water capacity is low. The content of organic matter is moderately low, and the fertility is low. The soils are droughty and are extremely susceptible to soil blowing.

The soils in this unit are used for small grain, grass, and legumes.

Crop residue should be left undisturbed between harvest and seeding to help control soil blowing. Cover crops are needed in years when there is not enough crop residue. It is best to use tillage implements that leave as much residue as possible on the surface. In stripcropping, the strips should be extremely narrow and grass should be grown at least half the time. Windbreaks are useful in control of erosion, but they are difficult to establish. Only early maturing crop varieties should be seeded.

CAPABILITY UNIT IVe-4L

This unit consists of deep, well-drained soils in the Barnes and Buse series. The surface layer and subsoil are loam. The slope is 3 to 9 percent.

Permeability is moderate in the upper part of these soils and moderately slow in the underlying material. The available water capacity is high. The content of organic matter is moderate in the Barnes soils and moderately low in the Buse soils. The fertility is high in the Barnes soils and medium in the Buse soils. In cultivated areas the surface layer of the Buse soils is limy and is susceptible to soil blowing. The hazard of erosion is moderate.

The soils in this unit are used for all locally grown crops.

Intensive use of crop residue and stubble mulching are needed to control erosion. Stripcropping and windbreaks also help to control erosion. Grassed waterways are needed in places where runoff water accumulates.

CAPABILITY UNIT IVe-6

Only Barnes loam, 9 to 12 percent slopes, is in this unit. It is a deep, well-drained soil. The surface layer and subsoil are loam.

Permeability is moderately slow, and the available water capacity is high. The content of organic matter is moderate, and the fertility is high. Because of the slope, erosion is a very severe hazard.

Only a small acreage of this soil is cultivated. Such intensive management of residue is required to control erosion that most areas are in native pasture or tame grass.

CAPABILITY UNIT IVw-4L

Only Marysland silt loam is in this unit. It is a poorly drained soil. It has a surface layer and subsoil of silt loam and is underlain by sand and gravel at a depth of 20 to 36 inches.

Permeability is moderate through the subsoil and very rapid below the subsoil, and the available water capacity is moderate. The content of organic matter and the fertility are high. The water table is high throughout most of the summer.

The soil is well suited to grass, and most areas are used for pasture and hay. It is too wet for cultivation unless it is artificially drained.

The major concern is that drainage is not feasible or practical in most areas. Hay should be mowed early enough to allow time for some regrowth before the ground freezes.

CAPABILITY UNIT IVs-6P

Only Cavour-Cresbard loams, 1 to 3 percent slopes, are in this unit. Both soils are deep and moderately well drained. They have a surface layer of loam. The Cresbard soil has a subsoil of clay loam that is a weak claypan, and the Cavour soil has a subsoil of clay that is a claypan and is very slowly permeable to water, air, and plant roots. When saturated, the claypan is soft, and it is slow to dry out. Where part of the subsoil has been mixed into the plow layer, the surface tends to crust over as it dries.

Both soils in this unit have a moderate content of organic matter. The available water capacity is moderate in the Cavour soil and high in the Cresbard soil. The fertility is medium in the Cavour soil and high in the Cresbard soil. The Cavour soil has salts in the subsoil, and the Cresbard soil has salts below the subsoil.

The soils are poorly suited to most crops commonly grown in the county. Small grain residue left undisturbed generally controls soil blowing until seeding time in spring but is not sufficient to protect the soil through a season of fallow. Flax seldom leaves enough residue to control soil blowing. Strip-cropping, cover crops, including grass and legumes in the cropping system, and other measures are required. Grass and legumes also help to maintain tilth. Trees do not grow satisfactorily on these soils.

CAPABILITY UNIT Vw-4

This unit consists of deep, poorly drained and very poorly drained soils of the Colvin, Fargo, and Ludden series. Excess water is on or near the surface of these soils during much of the growing season. The Colvin soil has a surface layer of silt loam and a subsoil of silty clay loam. The Fargo and Ludden soils have a surface layer and subsoil of silty clay.

All the soils in this unit have high available water capacity and high fertility. Permeability is moderately slow in the Colvin soil and slow in the Fargo and Ludden soils. The content of organic matter is high in the Colvin and Fargo soils and moderate in the Ludden soil.

The soils in this unit are not suitable for cultivation, but they are well suited to grass. In some years water is ponded deep enough that cattails and bulrushes grow instead of grass. Areas that are surrounded by cropped fields and that are too small to fence for use as pasture are used for hay or for fall grazing.

The growth of grass is not readily affected by periods of drought, nor is the grass likely to be overgrazed. Hay should be mowed early enough to allow time for some regrowth before the ground freezes. After mowing, there should be several inches of stubble in the field.

CAPABILITY UNIT VIe-5

This unit consists of deep, well-drained soils of the Zahl and Max series. These soils have a surface layer and subsoil of loam.

Permeability is moderate in the upper part of the profile and moderately slow in the underlying material. The available water capacity is moderate in the Max soils and high in the Zahl soils. The content of organic matter is moderately low in the Zahl soils. The fertility is high in the Max soils and medium in the Zahl soils.

The soils in this unit are too steep for cultivation. They are highly susceptible to erosion.

CAPABILITY UNIT VIe-6

This unit consists of deep soils of the Svea and Velva series. The surface layer is loam. The Svea soil has a subsoil of loam, and the Velva soil has a subsoil of silt loam. The Svea soil is moderately well drained, and the Velva soil is well drained.

Both soils in this unit have high available water capacity and high fertility. Permeability is moderate in the subsoil and moderately slow in the underlying material of the Svea soil, and it is moderate in the Velva soil. The content of organic matter is high in the Svea soil and moderate in the Velva soil.

These soils are so cut up by meandering stream channels and uncrossable drainageways that it is seldom possible or practical to farm them. They are often subject to flooding in spring.

CAPABILITY UNIT VIs-6

Only Sioux soils are in this unit. The surface layer is loam, and the subsoil is coarse sand and gravel. These soils are excessively drained.

Permeability is very rapid, and the available water capacity is very low. The content of organic matter is moderately low, and the fertility is low.

CAPABILITY UNIT VIIs-6

Only Barnes and Buse very stony loams, 3 to 15 percent slopes, are in this unit. These are deep, well-drained soils. The surface layer and subsoil are loam.

Permeability is moderate in the upper part of the profile and moderately slow in the underlying material, and the available water capacity is high. The content of organic matter is moderate in the Barnes soil and moderately low in the Buse soil. The fertility is high in the Barnes soil and medium in the Buse soil.

The soils in this unit are too stony to be cultivated, but they can be used for range.

CAPABILITY UNIT VIIIw-1

This unit consists entirely of areas of Marsh, which is covered by water most of the time. Except in dry years, Marsh is normally wet throughout the summer. Plants are mainly bulrushes and wetland sedges.

These areas have no value for farming, but they provide food and cover for ducks and other wildlife. In many places shallow ditches provide more permanent water.

CAPABILITY UNIT VIIIs-1

This unit consists only of Gravel pits. These areas have no value for farming. They are a source of sand and gravel and, when abandoned, often become good areas for wildlife habitat.

Predicted yields

Predicted yields of the principal crops grown in Renville County, under two levels of management, are shown in table 2. These predictions are based on information obtained from farmers, local farm workers, and the North Dakota Agricultural Experiment Station. They are averages for a period long enough to include years when temperature and moisture supply during the growing season were both favorable and unfavorable.

Woodland and Windbreaks [3]

Renville County has 4,200 acres of native woodland. The native woody vegetation is used mainly for livestock protection, wildlife habitat, recreational purposes, and watershed protection. Most of the trees and shrubs grow on the Velva, LaDelle, and Ludden soils on bottom lands along the Souris River. They also grow on the Svea and Max soils in natural draws leading into valleys of the Souris and Des Lacs Rivers. The principal trees and shrubs are boxelder, American elm, green ash, eastern cottonwood, willow, chokecherry, juneberry, wild plum, snowberry, wild rose, and aspen.

Windbreaks have been planted since the days of the early settlers. In most places the early planting protected the farmstead and livestock (fig. 21). A need for these kinds of plantings still exists on many farms. Increasingly windbreaks are planted to help control soil bowing in cultivated fields where it is a serious hazard. On thousands of acres in Renville County, some form of protection from wind is still needed.

[3] By DAVID L. HINTZ, woodland conservationist, Soil Conservation Service, Huron, S.D.

TABLE 2.—*Predicted average yield per acre*

[Yields in columns A can be expected under average management, and those in columns B can be expected under improved management. Dashes indicate that the crop is not suited to the soil. Only arable soils are listed]

Soil	Wheat		Barley		Oats		Rye		Flax		Alfalfa	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*
Arveson loam	12	19	16	20	22	28	13	20	5	9	----	----
Arvilla sandy loam, 6 to 9 percent slopes	7	11	9	12	13	16	6	11	3	6	0.8	1.3
Arvilla-Sioux sandy loams, 1 to 3 percent slopes	10	15	13	17	18	23	12	16	5	8	1.1	1.6
Arvilla-Sioux sandy loams, 3 to 6 percent slopes	8	13	10	14	14	18	10	15	4	7	1.0	1.5
Barnes loam, 1 to 3 percent slopes	20	30	26	34	36	46	19	28	8	12	1.2	1.8
Barnes loam, 3 to 6 percent slopes	19	29	25	32	34	44	18	27	7	11	1.1	1.7
Barnes loam, 6 to 9 percent slopes	14	22	18	24	25	32	15	24	6	11	1.1	1.6
Barnes loam, 9 to 12 percent slopes	11	17	14	18	20	25	11	19	5	9	1.0	1.6
Barnes cobbly loam, 1 to 6 percent slopes	18	28	23	31	32	41	18	27	7	11	1.1	1.7
Barnes-Buse loams, 3 to 6 percent slopes	17	25	22	29	31	39	16	24	7	11	.9	1.5
Barnes-Buse loams, 6 to 9 percent slopes	12	19	16	20	22	28	12	18	6	11	.8	1.4
Barnes-Cresbard loams, 1 to 3 percent slopes	19	27	25	32	34	44	20	28	7	11	1.1	1.7
Barnes-Hamerly loams, 3 to 6 percent slopes	19	27	25	32	34	44	11	20	6	9	1.0	1.8
Barnes-Hamlet-Tonka loams, 1 to 3 percent slopes	20	30	26	34	36	46	18	26	8	12	1.2	1.6
Barnes-Hamlet-Tonka loams, 3 to 6 percent slopes	19	29	25	32	34	44	17	25	7	11	1.1	1.5
Cavour-Cresbard loams, 1 to 3 percent slopes	12	18	16	20	22	28	13	20	5	7	.9	1.2
Colvin silt loam	17	25	22	29	31	39	16	24	6	10	----	----
Divide loam, loamy substratum, 1 to 3 percent slopes	16	25	21	27	29	37	16	25	6	9	1.2	1.8
Embden sandy loam, 1 to 6 percent slopes	17	25	22	29	31	39	17	25	6	9	1.3	2.0
Embden-Tiffany fine sandy loams, 1 to 3 percent slopes	17	25	22	29	31	39	17	25	6	9	1.3	2.0
Fargo silty clay	21	30	27	36	38	48	22	32	9	13	----	----
Fulda silty clay loam	18	28	23	32	32	42	18	29	7	12	----	----
Great Bend silty clay loam, 1 to 3 percent slopes	23	33	30	40	41	53	23	33	10	14	1.2	2.0
Hamerly loam, 1 to 3 percent slopes	20	28	26	34	36	46	19	28	6	9	1.2	1.6
Hamerly-Tonka loams, 1 to 3 percent slopes	19	27	25	32	34	44	18	26	6	10	1.2	1.6
Hamlet-Hamerly-Tonka loams, 1 to 3 percent slopes	21	29	27	36	38	48	20	29	7	10	1.2	1.8
Hamlet-Tonka loams, 1 to 3 percent slopes	22	30	29	37	40	51	20	29	7	10	1.2	1.7
Hecla and Lohnes loamy sands, 1 to 3 percent slopes	10	14	13	17	18	23	10	14	3	5	1.2	1.8
LaDelle silty clay loam, 1 to 3 percent slopes	24	33	31	41	43	55	25	35	10	14	1.2	2.0
Lohnes loamy sand, 3 to 6 percent slopes	7	10	9	12	13	16	7	10	3	4	1.0	1.5
Ludden silty clay	21	30	27	36	38	48	22	32	9	13	1.2	2.0
Marysland silt loam	17	24	22	29	31	39	16	24	6	9	----	----
Parnell silty clay loam	18	28	23	31	32	41	18	30	7	13	----	----
Renshaw loam, 1 to 3 percent slopes	11	16	14	19	20	25	12	17	6	9	1.3	1.9
Renshaw loam, 3 to 6 percent slopes	10	15	13	17	18	23	11	16	5	8	1.2	1.8
Svea loam, 1 to 3 percent slopes	23	33	30	39	41	53	23	33	10	14	1.2	2.0
Svea loam, 3 to 6 percent slopes	22	32	29	37	40	51	22	32	9	13	1.2	2.0
Svea loam, fans, 1 to 3 percent slopes	22	32	29	37	40	51	22	32	9	13	1.2	2.0
Svea loam, fans, 3 to 6 percent slopes	21	31	27	36	38	47	21	31	8	12	1.2	1.8
Swenoda fine sandy loam, 1 to 3 percent slopes	19	27	25	32	34	43	20	28	7	10	1.3	2.0
Swenoda fine sandy loam, 3 to 6 percent slopes	17	26	22	29	31	39	18	27	6	9	1.3	2.0
Tiffany fine sandy loam	16	23	21	27	29	37	16	25	6	10	1.2	2.0
Tonka silt loam	18	28	23	31	32	41	18	30	7	12	---	----
Vallers loam	17	24	22	29	31	39	15	24	6	10	----	----
Velva loam	17	27	22	29	31	39	16	26	9	13	1.2	2.0
Williams loam, 1 to 3 percent slopes	20	29	26	34	36	46	19	28	8	12	1.1	1.6
Williams loam, 3 to 6 percent slopes	19	28	25	32	34	44	18	27	7	11	1.0	1.5
Wyndmere fine sandy loam, 1 to 3 percent slopes	17	24	22	29	31	39	16	26	6	10	----	----

Among the many economic and environmental benefits of windbreaks are controlling snow and protecting the home and livestock from cold winds, thus reducing fuel and feed costs; protecting orchard and other crops from strong damaging winds; decreasing the evaporation of moisture; providing a suitable habitat for many kinds of wildlife; helping to control erosion; and enhancing the beauty of the homestead and its surroundings.

Establishment of a windbreak and continued growth of the trees depend on careful selection of the site, suitable preparation, and adequate maintenance. Consequently, before planting a windbreak, the purpose of the planting, the suitability of the soils, the adaptability of trees and shrubs, and the location should be considered. Grass and weeds have to be eliminated before the trees are planted, and the regrowth of the ground cover should be controlled for the entire life of the windbreak. Some replanting is likely to be needed in the first 2 years.

Descriptions of windbreak groups

The soils of North Dakota are grouped into 10 windbreak suitability groups. The soils of Renville County are

Figure 21.—**A good farmstead windbreak that provides protection for buildings. The soil is Barnes loam.**

in all of these groups. If good management practices are applied, the growth response for adapted trees and shrubs is generally the same for all of the soils within one group.

Several factors are used in grouping soils into windbreak suitability groups, but the dominant and most critical factor is the amount and seasonal availability of soil moisture to trees. In most windbreak groups the soils have a rather wide range of slope and of texture of the surface layer. These two soil characteristics largely determine the degree of hazards of water erosion and soil blowing. The degree of slope also determines the need for water and soil conservation practices on soils that have no other limiting characteristics.

The degree of susceptibility to soil blowing is determined by texture of soils used for windbreaks, as follows: soil that is coarse textured has a very high susceptibility; moderately coarse textured, high; medium textured, moderate to slight; moderately fine textured, slight; and fine textured, high. The degree of susceptibility to water erosion is determined by slope of soils used for windbreaks, as follows: soil that has a slope of 0 to 3 percent has no to slight susceptibility; 3 to 6 percent, moderate; 6 to 9 percent, high; 9 to 12 percent, high to very high; and 12 percent or more, very high.

All soils that are suited and planted to windbreaks and have slopes of more than 6 percent need water conservation practices if growth of trees is to be satisfactory. All soils that are susceptible to soil blowing or erosion need specialized site preparation, planting, and cultivation practices if plantings are to be successfully established and maintained. The water table is beyond the reach of tree roots in all soils in windbreak suitability groups 3 to 10, except for several soils in group 10. Some soils in group 10 are very wet during at least part of the year and have additional critical limitations to use for growing trees and shrubs.

Table 3 lists most of the trees and shrubs used in windbreak plantings and shows their estimated average height and vigor in well-managed plantings at 20 years of age. Considered in making the ratings in the columns headed "Vigor" were density of foliage, freedom from damaging insects or plant disease, and general appearance of the tree.

Good means that the plant generally exhibits leaves or needles that are normal in color and growth; only a small amount of deadwood (tops, branches, and twigs) within the live crown; limited evidence of damage from plant diseases, insects, or climate; or only slight evidence, in places, of stagnation or suppression. The plant may exhibit more than one of those features.

Fair means that the plant exhibits leaves or needles that are obviously abnormal in color and growth; a substantial amount of deadwood (tops, branches, and twigs) within the live crown; obvious evidence of moderate damage from plant diseases, insects, or climate; definite suppression or stagnation; or obviously less than normal growth in the current year. The plant may exhibit more than one of these features.

Poor means that the plant exhibits leaves or needles that are very abnormal in color and growth; a large amount of deadwood (tops, branches, and twigs) within the live crown; obvious evidence of extensive damage from plant diseases, insects, or climate; the effects of severe stagnation, suppression, or decadence; and essentially negligible growth in the current year. Plants that have this rating are not recommended for farmstead, feedlot, or field windbreaks. They may be satisfactory for some wildlife and beautification plantings.

In the following pages the windbreak suitability groups in Renville County are described.

WINDBREAK SUITABILITY GROUP 1

This group consists of deep, nearly level to sloping, well-drained to poorly drained, loamy or clayey soils of the Divide, Embden, Fargo, Great Bend, Hamerly, Hamlet, Hecla, LaDelle, Ludden, Svea, Velva, and Wyndmere series. These soils have favorable soil moisture for the survival and growth of trees and shrubs. The water table in the Divide, Hamerly, and Wyndmere soils is within the reach of tree roots. The Fargo, Great Bend, Hamlet, and Svea soils receive runoff from surrounding higher areas.

These soils are well suited to all kinds of windbreak plantings.

With the exception of a serious hazard of soil blowing on some soils, no other hazards or limitations to planting trees and shrubs on the soils in this group are serious.

WINDBREAK SUITABILITY GROUP 2

This group consists of deep, nearly level, poorly drained and very poorly drained, loamy or clayey soils of the Arveson, Colvin, Fulda, Marysland, Parnell, Tiffany, Tonka, and Vallers series. These soils are ponded or have a high water table. Unless drained, they are either poorly suited or not suited to trees and shrubs.

These soils are well suited to all kinds of windbreak plantings if adequate drainage is installed. The number of adapted trees and shrubs is more limited on the Arveson, Colvin, Marysland, and Vallers soils than on other soils in this group.

The hazard of soil blowing is serious on Colvin, Marysland, and Vallers soils because they have a high content of lime. Soil blowing is also a hazard on the clayey soils. Wetness is the only critical limitation, but to a lesser extent, high content of lime is also a limitation.

WINDBREAK SUITABILITY GROUP 3

This group consists of deep, nearly level to hilly, well-drained, loamy soils of the Barnes, Max, Svea, and Williams series.

These soils are well suited to all kinds of windbreak plantings. If proper care is given to conserving moisture, nearly all adapted trees and shrubs can be grown on these soils.

With the exception of a hazard of soil blowing or water erosion on some soils, other hazards or limitations to the planting of trees and shrubs on the soils in this group are not serious. On most of these soils a hazard of soil blowing is only slight.

WINDBREAK SUITABILITY GROUP 4

This group consists of deep, nearly level, moderately well drained, loamy soils of the Cresbard series. These soils have a clayey subsoil.

These soils are suited to all kinds of windbreak plantings if the trees and shrubs are carefully selected. Only a limited number of tree and shrub species do well on these soils.

The hazards of soil blowing and water erosion are slight. The only critical limitation is the clayey texture of the subsoil.

WINDBREAK SUITABILITY GROUP 5

This group consists of deep, nearly level to gently undulating, moderately well drained, sandy soils of the Swenoda series. Most of the precipitation is absorbed by these soils, but some is lost through runoff. The available water capacity is moderate.

These soils are suited to all kinds of windbreak plantings if trees and shrubs are carefully selected. Only a limited number of trees and shrubs do well.

The hazard of erosion is serious on these soils. The moderate available water capacity is the main limitation.

WINDBREAK SUITABILITY GROUP 6

This group consists of nearly level to sloping, somewhat excessively drained, loamy or sandy soils of the Arvilla and Renshaw series. These soils are shallow to sand and gravel. Most of the precipitation is absorbed by these soils, but it moves very rapidly through the sand and gravel underlying material. The available water capacity is low or moderate.

The hazard of erosion is slight to serious. The low available water capacity and a restricted root zone are the critical limitations.

These soils are poorly suited to all kinds of windbreak plantings. Some plantings can be established in areas where optimum survival, growth, and vigor should not be expected and if the proper plants are selected.

WINDBREAK SUITABILITY GROUP 7

This group consists of deep, nearly level to gently undulating, moderately well drained, sandy soils of the Lohnes series.

Most of the precipitation is absorbed by these soils, but little is retained. The available water capacity is low.

These soils are poorly suited to field windbreaks. They are suited to plantings for wildlife, recreation, and beautification in areas where optimum survival, growth, and vigor are not required or expected, but only a limited number of trees or shrubs can be selected.

Soil blowing is a serious hazard and water erosion a slight to moderate hazard. The low available water capacity is the main limitation.

WINDBREAK SUITABILITY GROUP 8

This group consists of deep, gently undulating to steep, well-drained, loamy soils of the Buse and Zahl series. Much of the precipitation runs off these soils. The available water capacity is high, but because runoff is excessive, the amount of water available to trees and shrubs is limited.

These soils are not suited to field windbreaks. They are suited to plantings for wildlife, recreation, and beautification in areas where optimum survival, growth, and vigor are not required or expected.

Erosion is a very serious hazard. Slope is the main limitation; consequently, runoff is excessive and water intake is low.

WINDBREAK SUITABILITY GROUP 9

This group consists of deep, nearly level, moderately well drained, loamy soils of the Cavour series. These soils have a dense claypan subsoil. A nonsodic and nonsaline root zone is generally less than 20 inches thick. The available water capacity is moderate.

TABLE 3.—*Height and vigor of trees and*

Trees and shrubs	Windbreak suitability group [1]					
	1		2		3	
	Vigor	Height	Vigor	Height	Vigor	Height
		Ft		*Ft*		*Ft*
American elm	Good	22–27	Good	20–25	Good	20–25
Black Hills spruce and Colorado blue spruce	Good	16–20	Good	15–18	Good	15–18
Caragana	Good	9–11	Fair	7–9	Good	8–10
Chokecherry	Good	11–14	Good	9–11	Good	10–12
Cottonwood	Good	40–48	Good	38–45	Poor	
Eastern redcedar or Rocky Mountain juniper	Good	11–13	Good	11–13	Good	12–15
Green ash	Good	21–26	Good	21–26	Good	20–25
Honeysuckle	Good	8–10	Good	7–9	Good	8–10
Ponderosa pine	Good	18–22	Good	20–22	Good	18–22
Russian-olive	Fair	15–19	Fair	15–19	Fair	14–18
Siberian elm	Good	28–35	Fair	28–32	Good	26–32
Wild plum	Good	7–9	Good	6–7	Good	8–10

[1] Height measurements and vigor ratings are for trees at 20 years of age. The soils in groups 9 and 10 are not suitable for trees and

These soils are not suited to any kind of windbreak planting, but they occur in complex with soils that are suitable for trees and shrubs that are planted by hand and used for wildlife, recreation, or beautification.

The hazards of soil blowing and water erosion are slight. A restricted root zone, moderate available water capacity, and salts in toxic amounts are the main limitations.

WINDBREAK SUITABILITY GROUP 10

This group consists of soils of the Barnes, Buse, Colvin, Fargo, Ludden, Sioux series, and Marsh and Gravel pits. The Barnes soils are very stony or very steep; the Buse soils are very stony; the Colvin, Fargo, and Ludden soils are very wet or channeled; and Sioux soils have gravel and sand at a depth of less than 10 inches. These soils have a wide range of texture, drainage, and slope; they all have one or more highly critical limitations to the survival, vigor, and growth of trees and shrubs. Some of the soils are waterlogged; some have low available water capacity; or others are too stony, steep, infertile, restrictive to roots, or erodible to be suited to trees and shrubs.

These soils are generally not suited to windbreak plantings. Gravel pits and the stony Barnes and Buse soils can be hand-planted to shrubs and trees for the purposes of wildlife, recreation, and beautification if proper care is given to the selection of the planting site and to the choice of adapted trees and shrubs.

The hazard of erosion is slight to serious. The main limitations are wetness, stoniness, slope, low fertility, low available water capacity, or depth of the root zone, depending on the particular soil.

Wildlife [4]

Wildlife in Renville County provide a major source of outdoor recreation, and they also contribute to the economy of the county. The kinds of wildlife changed drastically after the county was settled and a farming economy developed, but the kinds of birds have not changed so drastically as the kinds of mammals. Settlement provided a better habitat for cottontail rabbits and robins. Wild geese, cranes, and other birds were replaced to some degree when pheasant and gray partridge were introduced. Present-day mammals are those generally compatible with farming. At present the most numerous birds and animals in Renville County are waterfowl, sharp-tailed grouse, pheasant, gray partridge, and white-tailed deer. Less numerous are mourning dove, cottontail rabbit, and fox squirrel. The furbearers are mink, beaver, muskrat, weasel, red fox, and jackrabbit.

Public fishing is provided on the Souris River, Lake Darling, and a segment of the Des Lacs River. Some private ponds have been developed, but they provide only a limited amount of fishing. Small fishponds have been developed along the Souris River and the Des Lacs River. The most commonly sought fish are walleye, northern pike, perch, and bullhead.

Most wildlife habitat is created, improved, or maintained by managing existing vegetation, planting suitable vegetation, inducing the natural regeneration of desired plants, moving earth to enhance wildlife habitat, or a combination of these practices.

In table 4 the suitability of soils, by series, is shown for six elements of wildlife habitat and for three kinds of wildlife. Not considered in these interpretations were present land use, relationship of one soil to another, and size, shape, or extent of soil areas. Also disregarded was the mobility of wildlife. The suitability ratings should be used to help select sites for general kinds of wildlife habitat, guide the choice of a suitable soil for a needed habitat, or indicate the intensity of management needed to produce satisfactory results. They also help to show where management practices for desired wildlife can best be applied and what management practices should be used.

[4] By ERLING B. PODOLL, biologist, Soil Conservation Service, at Bismark.

shrubs by windbreak suitability group

Windbreak suitability group [1]—Continued									
4		5		6		7		8	
Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
	Ft		*Ft*		*Ft*		*Ft*		*Ft*
Fair	15–19	Fair	15–19	Fair	14–18	Poor		Poor	
Fair	15–18	Poor		Poor		Poor		Poor	
Good	6–8	Good	8–10	Fair	7–9	Fair	5–7	Fair	5–7
Good	8–10	Good	8–10	Fair	7–9	Poor		Poor	
Poor		Poor		Poor		Poor		Poor	
Good	10–12	Good	9–11	Fair	8–10	Fair	7–9	Fair	7–9
Good	16–20	Fair	15–19	Fair	14–18	Poor		Fair	14–18
Good	6–8	Good	7–9	Fair	6–8	Poor		Poor	
Good	17–19	Good	15–20	Fair	14–18	Fair	12–15	Fair	11–14
Fair	12–15	Fair	11–14	Fair	11–14	Poor		Fair	11–14
Good	22–26	Good	20–25	Fair	17–22	Fair	14–18	Fair	14–18
Good	7–9	Good	7–9	Fair	6–8	Poor		Poor	

shrubs.

The elements of wildlife habitat in table 4 were selected and weighed for openland, rangeland, and wetland wildlife. Those elements selected and weighed for openland wildlife were grain and seed crops, domestic grasses and legumes, wild herbaceous plants, and shrubs; those for rangeland wildlife were wild herbaceous plants and shrubs; and those for wetland wildlife are wetland plants and shallow water areas.

Openland or farmland wildlife are generally introduced wildlife or other wildlife that tolerate or depend upon areas where soil has been disturbed or annual plants are growing. Among these are gray partridge, pheasant, cottontail rabbit, red fox, goldfinch, and ground squirrel.

Rangeland wildlife are animals that depend on range plants. Among these are white-tailed deer, sharp-tailed grouse, horned lark, and jackrabbit.

Wetland wildlife are animals that normally depend on areas of natural wetland. Among these are ducks, herons, shorebirds, mink, muskrat, geese, and coot.

Suitability as a habitat for woodland wildlife is not shown because there is only a limited acreage of natural woodland in the county. These small wooded tracts provide habitat for animals and birds that need only small habitat niches. Among these are thrushes, vireos, and tree squirrels.

Recreation

Most recreation development in Renville County is at Mohall State Park and Mouse River State Park. Other recreation developments are limited. The major activities at these two parks are swimming, ice skating, outdoor games, trap shooting, and golfing. No public facilities are provided in the county for hiking, paths and trails, or camping. Federal wildlife refuge lands are the only public lands that provide such outdoor activities as hiking and nature study.

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. The limitations of the soils in Renville County that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails are given in table 5. The degree of limitation to the specified uses of the soils are given as slight, moderate, or severe. It is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. *Moderate* means that the limitation can be overcome or modified by planning, design, or special maintenance. *Severe* means that costly soil reclamation, special design, intense maintenance, or a combination of these is required.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have mild slopes, good drainage, a surface free of rocks and coarse fragments, are not subject to flooding during periods of heavy use, and a surface that is firm after rain but not dusty when dry.

Picnic areas are natural or landscaped tracts that withstand heavy foot traffic. Most of the vehicular traffic is confined to access roads. The best soils are firm when wet but not dusty when dry, are not subject to flooding during the season of use, and do not have slopes or stoniness that can greatly increase the cost of leveling or the building of access roads.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrops. They have good drainage and are not subject to flooding during periods of heavy use. Their surface is firm after rain but not dusty when dry. If grading and leveling are required, depth to rock is important.

Paths and trails are used for local and cross-country travel by foot or horseback. Design and layout should

TABLE 4.—*Soil interpretations for wildlife*

Soil series and map symbols	Suitability of the soils for —								
	Grain and seed crops	Domestic grasses and legumes	Wild herbaceous plants	Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Rangeland wildlife	Wetland wildlife
Arveson: Ar	Fair	Fair	Good	Fair	Good	Poor	Fair	Fair	Fair.
Arvilla: AvC, AwA, AwB For Sioux part of AwA and AwB, see that series.	Fair	Good	Fair	Poor	Very poor	Very poor	Fair	Poor	Very poor.
Barnes: BaA, BaB, BdB, BfA, BgB, BhA, BhB. For Buse part of BdB, BdC, and BnD, see that series. For Cresbard part of BfA and Hamlet part of BhA, see those series. For Hamerly part of BgB and Hamlet part of BhB, see those series. For Tonka part of BhA and BhB, see that series.	Good	Good	Good	Fair	Poor	Very poor	Good	Fair	Very poor.
BaC, BdC	Fair	Good	Good	Fair	Poor	Very poor	Good	Fair	Very poor.
BaD	Fair	Good	Good	Fair	Very poor	Very poor	Good	Fair	Very poor.
BbB	Good	Good	Good	Fair	Poor	Very poor	Good	Fair	Very poor.
BnD	Very poor	Very poor	Good	Fair	Poor	Very poor	Poor	Fair	Very poor.
Buse: Buse part of BdB, BdC	Fair	Good	Fair	Fair	Poor	Very poor	Fair	Fair	Very poor.
Buse part of BnD	Very poor	Very poor	Fair	Fair	Very poor	Very poor	Poor	Fair	Very poor.
Cavour: CaA For Cresbard part, see that series.	Poor	Poor	Fair	Very poor	Poor	Poor	Poor	Poor	Poor.
Colvin: Co	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
Cp	Very poor	Poor	Fair	Poor	Good	Good	Poor	Poor	Good.
Cr	Very poor	Poor	Poor	Poor	Good	Good	Poor	Poor	Good.
Cresbard	Fair	Good	Good	Poor	Poor	Poor	Fair	Fair	Poor.
Divide: DdA	Fair	Fair	Good	Fair	Poor	Poor	Fair	Fair	Poor.
Embden: EmB, EoA For Tiffany part of EoA, see that series.	Fair	Good	Good	Fair	Very poor	Very poor	Good	Fair	Very poor.
Fargo: Fa	Good	Good	Fair	Very poor	Poor	Good	Fair	Poor	Fair.
Fb	Very poor	Poor	Poor	Very poor	Poor	Good	Poor	Poor	Fair.
Fulda: Fu	Fair	Fair	Fair	Poor	Good	Good	Fair	Poor	Good.
Gravel pits: Gp	Very poor	Very poor	Poor	Fair	Very poor	Very poor	Very poor	Poor	Very poor.
Great Bend: GrA	Good	Good	Good	Poor	Poor	Poor	Good	Fair	Poor.

Hamerly: HaA, HbA For Tonka part of HbA, see that series.	Good	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
Hamlet: HhA, HmA For Hamerly part of HhA and for Tonka parts of HhA and HmA, see those series.	Good	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
Hecla: HoA For Lohnes part, see that series.	Fair	Good	Fair	Fair	Poor	Very poor	Fair	Fair	Very poor.
LaDelle: LaA	Good	Good	Good	Poor	Poor	Poor	Good	Fair	Poor.
Lohnes	Fair	Good	Fair	Fair	Poor	Very poor	Fair	Fair	Very poor.
Ludden:									
Lu	Good	Good	Fair	Very poor	Poor	Good	Fair	Poor	Fair.
Ly	Very poor	Poor	Poor	Poor	Poor	Good	Poor	Poor	Fair.
Marsh: Ma	Very poor	Very poor	Very poor	Very poor	Good	Good	Very poor	Very poor	Good.
Marysland: Mb	Poor	Fair	Fair	Fair	Good	Fair	Fair	Fair	Fair.
Max:									
Max part of ZaD	Poor	Fair	Good	Fair	Very poor	Very poor	Fair	Fair	Very poor.
Max part of ZaF	Very poor	Very poor	Good	Fair	Very poor	Very poor	Poor	Fair	Very poor.
Parnell: Pa	Fair	Fair	Fair	Poor	Good	Good	Fair	Poor	Good
Renshaw: RnA, RnB	Fair	Fair	Fair	Poor	Very poor	Very poor	Fair	Poor	Very poor.
Sioux: SoB, SoD	Poor	Poor	Poor	Poor	Very poor	Very poor	Poor	Poor	Very poor.
Svea:									
SvA, SyA	Good	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
SvB, SyB	Good	Good	Good	Fair	Poor	Very poor	Good	Fair	Very poor.
SwB	Poor	Fair	Good	Fair	Poor	Very poor	Fair	Fair	Very poor.
Swenoda:									
SzA	Fair	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
SzB	Fair	Good	Good	Fair	Poor	Very poor	Good	Fair	Very poor.
Tiffany: Tf	Fair	Fair	Good	Fair	Fair	Fair	Fair	Fair	Fair.
Tonka: To	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
Vallers: Va	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
Velva:									
Vb	Good	Good	Good	Fair	Poor	Poor	Good	Fair	Poor.
Vd	Poor	Fair	Good	Fair	Poor	Very poor	Fair	Fair	Very poor.
Williams: WmA, WmB	Good	Good	Good	Fair	Poor	Very poor	Good	Fair	Very poor.
Wyndmere: WyA	Fair	Good	Good	Fair	Fair	Fair	Good	Fair	Fair.
Zahl:									
ZaD For Max part, see that series.	Poor	Fair	Fair	Fair	Very poor	Very poor	Fair	Fair	Very poor.
ZaF For Max part, see that series.	Very poor	Very poor	Fair	Fair	Very poor	Very poor	Poor	Fair	Very poor.

TABLE 5.—*Soil interpretations for recreation*

Soil series and map symbols	Degree and kind of limitations for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Arveson: Ar	Severe: poor drainage and water table.	Severe: poor drainage and water table.	Severe: poor drainage and water table.	Severe: poor drainage and water table.
Arvilla:				
AvC	None to slight	None to slight	Severe: slope	None to slight.
AwA	None to slight	None to slight	None to slight	None to slight.
AwB	None to slight	None to slight	Moderate: slope	None to slight.
Barnes:				
BaA, BfA, BhA. For Cresbard part of BfA and Hamlet part of BhA, see those series.	Moderate: permeability.	None to slight	Moderate: permeability.	None to slight.
BaB, BdB, BgB, BhB. For Hamerly part of BgB and Hamlet part of BhB, see those series.	Moderate: permeability.	None to slight	Moderate: slope	None to slight.
BaC, BdC	Moderate: permeability.	None to slight	Severe: slope	None to slight.
BaD	Moderate: slope	Moderate: slope	Severe: slope	None to slight.
BbB	Moderate: cobbles	Moderate: cobbles	Severe: cobbles	Moderate: cobbles.
BnD	Severe: stones	Moderate: stones	Severe: stones	Severe: stones.
Buse: Mapped only with Barnes soils. See BdB, BdC, and BnD under Barnes series.				
Cavour: CaA	Moderate: permeability.	None to slight	Moderate: permeability.	None to slight.
Colvin:				
Co, Cp	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.
Cr	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.
Cresbards: Mapped only with Barnes and Cavour series. See Cavour series.				
Divide: DdA	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Embden:				
EmB	None to slight	None to slight	Moderate: slope	None to slight.
EoA. For Tiffany part, see that series.	None to slight	None to slight	None to slight	None to slight.
Fargo:				
Fa	Severe: surface texture and poor drainage.	Severe: surface texture and poor drainage.	Severe: surface texture and poor drainage.	Severe: surface texture and poor drainage.
Fb	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.	Very severe: wetness.
Fulda: Fu	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.
Gravel pits: Gp	Severe: slope and cobbles.	Severe: slope and cobbles.	Severe: slope and cobbles.	Severe: slope and cobbles.
Great Bend: GrA	Moderate: surface texture.	Moderate: surface texture.	Moderate: surface texture.	Moderate: surface texture.
Hamerly: HaA, HbA. For Tonka part of HbA, see that series.	Moderate: permeability.	Moderate: flood hazard.	Moderate: permeability.	None to slight.

TABLE 5.—*Soil interpretations for recreation*—Continued

Soil series and map symbols	Degree and kind of limitations for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Hamlet: HhA, HmA For Hamerly part of HhA and for Tonka parts of HhA and HmA, see those series.	Moderate: permeability.	None to slight	Moderate: permeability.	None to slight.
Hecla: HoA For Lohnes part, see that series.	Moderate: surface texture.	Moderate: surface texture.	Moderate: surface texture.	Moderate: surface texture.
LaDelle: LaA	Moderate: flood hazard and surface texture.	Moderate: flood hazard and surface texture.	Moderate: flood hazard and surface texture.	Moderate: surface texture.
Lohnes:				
Lohnes part of HoA	Moderate: surface texture.	Moderate: surface texture.	Moderate: surface texture.	Moderate: surface texture.
LoB	Moderate: surface texture.	Moderate: surface texture.	Moderate: surface texture and slope.	Moderate: surface texture.
Ludden:				
Lu	Severe: poor drainage and surface texture.	Severe: poor drainage and surface texture.	Severe: poor drainage and surface texture.	Severe: poor drainage and surface texture.
Ly	Very severe: wetness	Very severe: wetness	Very severe: wetness	Very severe: wetness.
Marsh: Ma	Very severe: wetness	Very severe: wetness	Very severe: wetness	Very severe: wetness.
Marysland: Mb	Severe: poor drainage	Severe: poor drainage	Severe: poor drainage	Severe: poor drainage.
Max: Mapped only with Zahl soils.				
Parnell: Pa	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.
Renshaw:				
RnA	None to slight	None to slight	None to slight	None to slight.
RnB	None to slight	None to slight	Moderate: slope	None to slight.
Sioux:				
SoB	None to slight	None to slight	Moderate: slope	None to slight.
SoD	Moderate: slope	Moderate: slope	Severe: slope	None to slight.
Svea:				
SvA, SvB, SyA, SyB	Moderate: permeability.	None to slight	Moderate: permeability.	None to slight.
SwB	Moderate: permeability.	None to slight	Moderate: permeability and slope.	None to slight.
Swenoda:				
SzA	None to slight	None to slight	None to slight	None to slight.
SzB	None to slight	None to slight	Moderate: slope	None to slight.
Tiffany: Tf	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Tonka: To	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.
Vallers: Va	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.	Severe: poor drainage.
Velva:				
Vb	Moderate: flood hazard.	None to slight	None to slight	None to slight.
Vd	Moderate: flood hazard.	None to slight	Moderate: slope	None to slight.

TABLE 5.—*Soil interpretations for recreation*—Continued

Soil series and map symbols	Degree and kind of limitations for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Williams:				
WmA	Moderate: permeability.	None to slight	Moderate: permeability.	None to slight.
WmB	Moderate: permeability.	None to slight	Moderate: slope and permeability.	None to slight.
Wyndmere: WyA	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Zahl:				
ZaD	Moderate: slope	Moderate: slope	Severe: slope	None to slight.
ZaF	Severe: slope	Severe: slope	Very severe: slope	Moderate to severe: slope.

need little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

Engineering Uses of the Soils [5]

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, so that the performance of structures on the same or similar kinds of soil in other places can be predicted.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables. Table 6 shows several estimated soil properties significant to engineering; table 7 gives interpretations for various engineering uses; and table 8 gives soil features affecting land uses.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those in the tables. It also can be used to make other useful maps.

This information, however, does not eliminate the need for further investigations at sites selected for engineering works, especially works that involve heavy loads or require excavations to depths greater than those shown in the tables, generally depths of more than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning in soil science. The Glossary defines many of these terms.

Classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*2*), used by the Soil Conservation Service, Department of Defense, and other agencies, and the AASHTO system (*1*), adopted by the American Association of State Highway and Transportation Officials.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and content of organic matter. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as

[5] By ORVAL C. HOVEY, agricultural engineer, and CLINTON R. JOHNSON, State conservation engineer, Soil Conservation Service.

Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, SP–SM.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system a soil is placed in one of seven basic groups that range from A–1 to A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7; and A–7–5 and A–7–6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest.

Significant soil properties

Several estimated soil properties significant to engineering are shown in table 6. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Bedrock is at a depth of more than 6 feet for all of these soils. Following are explanations of some of the columns in table 6.

Depth to seasonal water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in table 6 in the standard terms used by the Department of Agriculture. These terms take into account the relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic. If the moisture content is further increased, the material changes from a plastic to a liquid. The plastic limit is the moisture content at which the soil material changes from semisolid to plastic; and the liquid limit, from a plastic to a liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 6.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 6 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed as a pH value. The pH value and terms used to describe soil reaction are explained in the Glossary.

Salinity refers to the amount of soluble salts in the soil. It is expressed as the electrical conductivity of the saturation extract, in millimhos per cubic centimeter at 25° C. Salinity affects the suitability of a soil for crops, its stability when used as construction material, and its corrosiveness to metals and concrete.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material that has this rating.

Corrosivity, as used in table 6, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The corrosion of uncoated steel is related to such soil properties as drainage, texture, total acidity, and electrical conductivity of the soil material. Corrosivity to concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations made entirely in one kind of soil or in one soil horizon. A corrosivity rating of *low* means that there is a low probability of soil-induced corrosion damage. A rating of *high* means that there is a high probability of damage, so that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

Interpretations of soils

The estimated interpretations in table 7 and soil features in table 8 are based on the engineering properties of soils shown in table 6, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Renville County. In table 7, summarized limitations or ratings of suitability of the soils are given. Table 8 lists those soil features not to be overlooked in planning, installation, and maintenance.

In table 7 the degrees of limitation are expressed as slight, moderate, severe, and very severe. *Slight* means that soil properties are generally favorable for the given use or, that limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means that soil properties are so unfavorable and so difficult to correct that major soil reclamation and special design are needed.

TABLE 6.—*Estimated engineering*

[Bedrock is at a depth of more than 6 feet in all soils.

Soil series and map symbols	Depth to seasonal water table	Depth from surface	Dominant USDA texture	Classification		Percentage less than 3 inches passing sieve—	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Arveson: Ar	[1] 1–3	0–14	Loam	ML	A–4	100	100
		14–23	Sandy loam	SM	A–2–4, A–4	100	100
		23–60	Sand	SP–SM	A–3, A–2–4	100	100
Arvilla: AvC, AwA, AwB	>5	0–15	Sandy loam	SM	A–2–4	90–100	85–100
		15–60	Gravel and sand	SP–SM	A–1	85–95	60–80
For Sioux parts of AwA and AwB, see that series.							
Barnes: BaA, BaB, BaC, BaD, BdB, BdC, BfA, BgB, BhA, BhB, BnD.	>5	0–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
For Buse part of BdB, BdC, and BnD, Cresbard part of BfA, Hamerly part of BgB, Hamlet part of BhA, and Tonka part of BhA and BhB, see those series.							
BbB	>5	0–60	Cobbly loam	ML or CL	A–4 or A–6	60–75	55–75
Buse	>5	0–60	Loam	ML or CL	A–4 or A–6	90–100	90–100
Cavour: CaA	>5	0–6	Loam	ML or CL	A–4 or A–6	95–100	90–100
		6–14	Clay	CL or CH	A–7	95–100	90–100
For Cresbard Part, see that series.		14–60	Clay loam	CL	A–6 or A–7	95–100	90–100
Colvin: Co, Cp, Cr	[1] 1–3	0–7	Silt loam	CL–ML or CL	A–4 or A–6	100	100
		7–60	Silty clay loam	CL	A–6 or A–7	100	100
Cresbard	>5	0–6	Loam	ML or CL	A–4 or A–6	95–100	90–100
		6–30	Clay loam	CL	A–6 or A–7	95–100	90–100
		30–60	Loam	CL	A–6	95–100	90–100
Divide: DdA	2–5	0–8	Loam	ML or CL	A–4 or A–6	95–100	90–100
		8–24	Gravelly sandy loam, gravelly loam.	SM	A–2 or A–4	70–85	65–80
		24–40	Fine gravel and sand	SM	A–1	70–100	25–60
		40–60	Loam	ML or CL	A–6	95–100	90–100
Embden: EmB, EoA	>5	0–24	Fine sandy loam, sandy loam.	SM	A–4	100	100
For Tiffany part of EoA, see that series.		24–48	Loamy fine sand	SM	A–2–4	100	100
		48–60	Sandy loam	SM	A–2–4 or A–4	100	100
Fargo: Fa, Fb	[1] 1–3	0–60	Silty clay	CH	A–7	100	100
Fulda: Fu	[1] 1–3	0–5	Silty clay loam	CL	A–7 or A–6	100	100
		5–29	Silty clay	CH	A–7	100	100
		29–60	Clay loam	CL	A–6 or A–7	95–100	90–100
Gravel pits: Gp. Properties are too variable to be estimated; onsite investigation is needed.							

See footnote at end of table.

properties of the soils

The symbol > means more than; the symbol < means less than]

Percentage less than 3 inches passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
		Pct		*In per hr*	*In per in of soil*	*pH*				
85–95	60–75	15–35	[2] NP–10	0. 6–2. 0	0. 20–0. 22	7. 4–8. 4	None to low.	Low.	High.	Low.
60–70	30–40	[2] NP	NP	2. 0–6. 0	0. 12–0. 14	7. 4–7. 8	None.	Low.	High.	Low.
50–70	5–12	NP	NP	6. 0–20	0. 05–0. 07	7. 4–7. 8	None.	Low.	High.	Low.
60–70	30–35	NP	NP	2. 0 6. 0	0. 13 0. 15	6. 6–7. 3	None.	Low.	High.	Low
30–50	5–10	NP	NP	>20	0. 03–0. 05	7. 4–7. 8	None.	Low.	Moderate.	Low.
85–95	60–75	25–40	5–20	0. 2–2. 0	0. 17–0. 19	6. 6–8. 4	None [3].	Moderate.	High.	Low.
50–60	25–50	25–40	5–20	0. 2–2. 0	0. 15–0. 17	7. 4–8. 4	None [3].	Moderate.	High.	Low.
85–95	60–75	25–40	5–20	0. 6–2. 0	0. 17–0. 19	6. 6–8. 4	None [3].	Moderate.	High.	Low.
85–95	60–75	25–40	5–20	0. 2–2. 0	0–17. 0. 19	7. 4–7. 8	None.	Moderate.	High.	Low.
90–100	75–95	40–60	20–40	0. 06–0. 2	0. 13–0. 15	8. 5–9. 0	Moderate to high.	High.	High.	Moderate to high.
90–100	70–80	30–50	10–30	<0. 06	0. 14–0. 16	7. 9–9. 0	Moderate to high.	Moderate to high.	High.	Moderate to high.
90–100	70–90	25–40	5–20	0. 6–2. 0	0. 22–0. 24	7. 4–7. 8	None or low.	Moderate.	High.	Low.
95–100	85–95	30–50	10–30	0. 2–0. 6	0. 16–0. 20	7. 9–8. 4	None or low.	High.	High.	Low to moderate.
85–95	60–75	25–40	5–20	0. 2–2. 0	0. 20–0. 22	6. 6–7. 3	None.	Moderate.	High.	Low.
90–100	70–80	30–50	10–30	0. 2–0. 6	0. 14–0. 16	7. 4–9. 0	Low to moderate.	Moderate to high.	High.	Moderate to high.
85–95	60–75	25–40	10–20	0. 2–0. 6	0. 17–0. 19	8. 5–9. 0	Low to moderate.	Moderate.	High.	Moderate to high.
85–95	60–75	20–40	5–20	0. 6–2. 0	0. 17 0. 19	7. 4–8. 4	None to low.	Moderate.	High.	Low.
45–55	30–40	NP	NP	0. 6–2. 0	0. 12–0. 14	7. 9–8. 4	None to low.	Low.	High.	Low.
15–40	12–25	NP	NP	>20	0. 03–0. 05	7. 4–8. 4	None.	Low.	High.	Low.
85–95	60–75	25–40	10–20	0. 2–0. 6	0. 17–0. 19	7. 4–8. 4	None [3].	Moderate.	High.	Low.
70–85	40–50	NP	NP	2. 0–6. 0	0. 16–0. 18	6. 6–7. 3	None.	Low.	High.	Low.
50–75	15–30	NP	NP	6. 0–20	0. 08–0. 10	6. 6–7. 3	None.	Low.	High.	Low.
60–70	30–40	NP	NP	2. 0–6. 0	0. 11–0. 13	7. 9–8. 4	None.	Low.	High.	Low
95–100	90–95	50–80	25–50	0. 06–0. 2	0. 14–0. 17	6. 6–8. 4	None.	High.	High.	Low.
95–100	85–95	30–50	10–30	0. 2–0. 6	0. 18–0. 23	6. 6–7. 3	None.	High.	High.	Low.
95–100	90–95	50–80	25–50	0. 06–0. 2	0. 14–0. 17	6. 6–7. 8	None.	High.	High.	Low.
90–100	70–80	30–50	10–30	0. 2–0. 6	0. 14–0. 16	7. 9 8. 4	None.	Moderate to high.	High.	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal water table	Depth from surface	Dominant USDA texture	Classification		Percentage less than 3 inches passing sieve—	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Great Bend: GrA	>5	0–24	Silty clay loam	CL	A–7 or A–6	100	100
		24–60	Clay loam	CL	A–6 or A–7	95–100	90–100
Hamerly: HaA, HbA. For Tonka part of HbA, see that series.	3–5	0–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
Hamlet: HhA, HmA. For Hamerly part of HhA and for Tonka parts of HhA and HmA, see those series.	>5	0–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
Hecla: HoA. For Lohnes part, see that series.	>5	0–40	Loamy sand	SM	A–2–4	100	100
		40–60	Medium and fine sand.	SM, SP–SM	A–2–4 or A–3	100	100
LaDelle: LaA. Below a depth of 40 inches, properties are too variable to be estimated; onsite investigation is needed.	[1] >5	0–26	Silty clay loam	CL	A–6 or A–7	100	100
		26–40	Loam, very fine sandy loam.	ML	A–4	100	100
Lohnes: LoB	>5	0–15	Loamy sand	SM	A–2–4	100	95–100
		15–60	Coarse and medium sand.	SP or SP–SM	A–1	80–100	40–60
Ludden: Lu, Ly	[1] 1–3	0–60	Silty clay	CH	A–7	100	100
Marsh: Ma. Properties are too variable to be estimated; onsite investigation is needed.							
Marysland: Mb	[1] <1	0–35	Silt loam	ML or CL	A–4 or A–6	100	100
		35–60	Gravel and sand	SM	A–1	60–100	30–60
Max	>5	0–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
Parnell: Pa	[1] 1–3	0–9	Silty clay loam	CL	A–6 or A–7	100	100
		9–44	Silty clay	CH	A–7	100	100
		44–60	Clay loam	CL	A–6 or A–7	95–100	90–100
Renshaw: RnA, RnB	>5	0–16	Loam	ML or CL	A–4 or A–6	90–100	85–100
		16–60	Gravel and sand	GP–GM, SP–SM	A–1	30–75	15–50
Sioux: SoB, SoD	>5	0–5	Loam	ML	A–4	85–100	80–100
		5–60	Sand and gravel	GW–GP, GM, SM, SW–SP	A–1	30–75	15–50
Svea: SvA, SvB, SwB, SyA, SyB	>5	0–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
Swenoda: SzA, SzB	>5	0–23	Fine sandy loam	SM	A–4	100	95–100
		23–60	Loam	ML or CL	A–4 or A–6	95–100	90–100

See footnotes at end of table.

properties of the soils—Continued

Percentage less than 3 inches passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
		Pct		*In per hr*	*In per in of soil*	*pH*				
95–100	85–95	30–50	10–30	0. 6–2. 0	0. 18–0. 23	6. 6–8. 4	None	High	High	Low.
90–100	70–80	30–50	10–30	0. 6–2. 0	0. 14–0. 16	7. 9–8. 4	None [3]	Moderate to high.	High	Low.
85–95	60 75	20–40	5–20	0. 2–2. 0	0. 17–0. 19	7. 9–8. 4	None to low.	Moderate	High	Low.
85–95	60–75	20–40	5–20	0. 06 2. 0	0. 17–0. 19	6. 6–8. 4	None [3]	Moderate	High	Low.
50–75	15–30	NP	NP	6. 0–20	0. 09–0. 11	6. 6–8. 4	None	Low	High	Low.
50–80	5–15	NP	NP	6. 0 -20	0. 05–0. 07	7. 9–8. 4	None	Low	High	Low.
95–100	85–95	30–50	10–30	0. 6–2. 0	0. 18 0. 23	6. 6–7. 8	None	High	High	Low.
85–100	60–75	15–35	NP–10	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	None	Low to moderate.	High	Low.
50–75	15–30	NP	NP	6. 0–20	0. 10–0. 12	6. 6–7. 8	None	Low	High	Low.
20–40	0–12	NP	NP	6. 0–20	0. 04–0. 06	7. 9–8. 4	None	Low	Moderate	Low.
95–100	90–95	50 80	25–50	0. 06–0. 2	0. 14–0. 17	7. 4–8. 4	None	High	High	Low.
90–100	70–90	15–40	5–20	0. 6–2. 0	0. 22–0. 24	7. 9–8. 4	None to low.	Low to moderate.	High	Low to moderate.
20–40	12–25	NP	NP	>20	0. 03–0. 05	7. 9–8. 4	None	Low	High	Low.
85–95	60 75	25 40	5–20	0. 2–2. 0	0. 17–0. 19	6. 6–8. 4	None [3]	Moderate	High	Low.
95–100	85–95	30–50	10–30	0. 2–0. 6	0. 18–0. 23	6. 6–7. 3	None	High	High	Low.
95–100	90 95	50 -80	20–50	0. 06–0. 2	0. 14–0. 17	6. 6–7. 8	None	High	High	Low.
90–100	70–80	30–50	10–30	0. 2–0. 6	0. 14–0. 16	7. 4–7. 8	None	High	High	Low.
70–90	50–70	20–35	5–20	0. 6 -2. 0	0. 17–0. 19	6. 6–7. 3	None	Low	High	Low.
8–40	5–12	NP	NP	>20	0. 03–0. 05	7. 4–7. 8	None	Low	Moderate	Low.
65–90	50–70	15–35	NP–10	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	None	Low	Moderate	Low.
8–40	0–25	NP	NP	>20	0. 03–0. 05	7. 4–8. 4	None	Low	Moderate	Low.
85–95	60–75	20–40	5–20	0. 2–2. 0	0. 17–0. 19	6. 6–8. 4	None [3]	Moderate	High	Low.
70–85	40 -50	NP	NP	2. 0–6. 0	0. 16–0. 18	6. 6–7. 3	None	Low	High	Low.
85–95	60–75	20–40	5–20	0. 2 -0. 6	0. 17–0. 19	7. 4–8. 4	None [3]	Moderate	High	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal water table	Depth from surface	Dominant USDA texture	Classification		Percentage less than 3 inches passing sieve—	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Tiffany: Tf	[1] 2–5	0–32	Sandy loam, fine sandy loam.	SM	A–2 or A–4	100	100
		32–46	Very fine sandy loam.	ML	A–4	100	100
		46–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
Tonka: To	[1] 1–3	0–14	Silt loam	ML	A–4	100	100
		14–36	Clay loam	CL	A–7 or A–6	100	100
		36–60	Loam	ML or CL	A–4 or A–6	95–100	90–100
Vallers: Va	[1] 1–3	0–60	Loam	CL–ML or CL	A–4 or A–6	95–100	90–100
Velva: Vb, Vd	[1] >5	0–8	Loam	ML	A–4	100	100
		8–19	Silt loam	ML	A–4	100	100
		19–60	Very fine sandy loam.	ML	A–4	100	100
Williams: WmA, WmB	>5	0–60	Loam	CL–ML or CL	A–4 or A–6	95–100	90–100
Wyndmere: WyA	[1] 3–5	0–26	Fine sandy loam	SM	A–4	100	100
		26–46	Loamy fine sand	SM	A–2	100	100
		46–60	Very fine sandy loam.	ML	A–4	100	100
Zahl: ZaD, ZaF For Max part, see that series.	>5	0–60	Loam	CL–ML or CL	A–4 or A–6	90–100	90–100

[1] Subject to flooding or ponding.
[2] NP means nonplastic.

properties of the soils—Continued

Percentage less than 3 inches passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
		Pct		*In per hr*	*In per in of soil*	*pH*				
60–70	30–45	NP	NP	0. 6–2. 0	0. 12–0. 14	6. 6–7. 3	None	Low	High	Low.
85–95	50–65	20–35	NP–10	0. 6–2. 0	0. 17–0. 19	7. 9–8. 4	None	Low	High	Low.
85–95	60–75	15–40	5–20	0. 6–2. 0	0. 17–0. 19	7. 4–8. 4	None [3]	Moderate	High	Low to moderate.
90–100	70–90	20–40	5–10	0. 6–2. 0	0. 22–0. 24	6. 6–7. 3	None	Moderate	High	Low.
90–100	70–80	30–50	10–30	0. 06–0. 6	0. 15–0. 19	6. 6–7. 8	None	Moderate to high.	High	Moderate.
85–95	60–75	25–40	5–20	0. 2–0. 6	0. 17–0. 19	7. 9–8. 4	None [3]	Moderate	High	Low.
85–95	60–75	20–40	5–20	0. 2–2. 0	0. 17–0. 19	7. 9–8. 4	None to low.	Moderate	High	Low.
85–100	60–75	15–35	NP–10	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	None	Low	High	Low.
90–100	70–90	25–35	5–10	0. 6–2. 0	0. 20–0. 24	7. 4–7. 8	None	Low	High	Low.
85–95	50–65	20–35	NP–10	2. 0–6. 0	0. 17–0. 19	7. 4–7. 8	None	Low	High	Low.
85–95	60–75	20–40	5–20	0. 2–2. 0	0. 17–0. 19	6. 6–8. 4	None [3]	Moderate	High	Low.
70–85	35–50	15–30	NP–10	2. 0–6. 0	0. 16–0. 18	7. 4–8. 4	None	Low	High	Low.
50–75	15–30	NP	NP	6. 0–2. 0	0. 09–0. 11	7. 4–7. 8	None	Low	High	Low.
85–95	50–65	20–35	NP–10	2. 0–6. 0	0. 17–0. 19	7. 4–7. 8	None	Low	High	Low.
85–95	60–75	20–40	5–20	0. 2–2. 0	0. 17–0. 19	7. 4–8. 4	None [3]	Moderate	High	Low.

[3] Crystals and nests of gypsum are common in the lower horizons.

TABLE 7.—*Interpretations*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basement
Arveson: Ar	Severe: seasonal high water table.	Severe: seasonal high water table; moderately rapid to rapid permeability.	Severe: poorly drained.	Severe: poorly drained; seasonal high water table above a depth of 30 inches.
Arvilla: AvC, AwA, AwB For Sioux part of AwA and AwB, see that series.	Slight: very rapid permeability; hazard of pollution.	Severe: very rapid permeability.	Severe: very gravelly material.	Slight
Barnes: BaA, BaB, BaC, BaD, BbB, BdB, BdC, BfA, BgB, BhA, BhB, BnD. For Buse part of BdB, BdC, and BnD, Cresbard part of BfA, Hamerly part of BgB, Hamlet part of BhA and BhB, and for Tonka part of BhA and BhB see those series.	Moderate to severe: moderately slow permeability.	Slight if slope is less than 3 percent. Moderate if slope is 3 to 6 percent. Severe if slope is more than 6 percent or in very stony areas.	Slight if slope is less than 9 percent. Moderate if slope is 9 to 15 percent. Severe if slope is more than 15 percent or in very stony areas.	Moderate: moderate shrink-swell potential.
Buse	Moderate: moderate permeability.	Moderate if slope is 3 to 9 percent. Severe if slope is more than 9 percent or in very stony areas.	Generally slight, but severe where very stony.	Moderate: moderate shrink-swell potential.
Cavour: CaA For Cresbard part, see that series.	Severe: very slow permeability.	Slight	Moderate: moderately well drained; clay.	Moderate: moderate shrink-swell potential.
Colvin: Co, Cp, Cr	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained.	Severe: poorly drained.
Cresbard	Severe: moderately slow permeability.	Slight	Moderate: moderately well drained.	Moderate: moderate shrink-swell potential.
Divide: DdA	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.
Embden: EmB, EoA For Tiffany part of EoA, see that series.	Slight	Severe: moderately rapid permeability to rapid permeability.	Moderate: moderately well drained.	Moderate: moderately well drained.
Fargo: Fa, Fb	Severe: slow permeability; poorly drained.	Severe: subject to flooding.	Severe: poorly drained; clay.	Severe: poorly drained; subject to flooding; high shrink-swell potential.
Fulda: Fu	Severe: slow permeability; poorly drained.	Severe: subject to flooding and ponding.	Severe: poorly drained; clay.	Severe: poorly drained; subject to flooding; high shrink-swell potential.

See footnote at end of table.

of engineering properties

Degree and kind of limitation for—Continued			Suitability as source of—		
Dwellings without basement	Sanitary landfill [1] (trench type)	Roads and streets	Road fill	Sand and gravel	Topsoil
Severe: poorly drained; seasonal high water table above a depth of 20 inches.	Severe: poorly drained.	Severe: poorly drained.	Poor: poorly drained.	Fair to poor for sand only: water table.	Poor: poorly drained.
Slight	Severe: very rapid permeability; soil texture.	Slight	Good	Fair	Poor: material too thin.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Generally slight, but severe where stony.	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Fair: 8 to 16 inches of material.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Generally slight, but severe where very stony.	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Poor: material too thin.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Moderate: clay loam.	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Poor: material too thin; soluble salts.
Severe: poorly drained.	Severe: water table; poorly drained.	Severe: poorly drained.	Poor: poorly drained; high frost action potential.	Unsuited	Poor: poorly drained.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Slight	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Fair: 8 to 16 inches of material.
Moderate: moderate frost action potential; somewhat poorly drained.	Severe: water table.	Moderate: moderate frost action potential; somewhat poorly drained.	Moderate: moderate frost action potential; somewhat poorly drained.	Fair to poor: layers may be too thin; water table.	Fair: 8 to 16 inches of material.
Moderate: moderate frost action potential.	Severe: permeability.	Moderate: moderate frost action potential.	Fair: moderate frost action potential.	Poor for sand only	Good.
Severe: poorly drained; subject to flooding; high shrink-swell potential.	Severe: poorly drained; subject to flooding; clay.	Severe: poorly drained; high shrink-swell potential.	Poor: high shrink-swell potential.	Unsuited	Poor: poorly drained; silty clay.
Severe: poorly drained; subject to flooding; high shrink-swell potential.	Severe: poorly drained; subject to flooding; clay.	Severe: poorly drained; high shrink-swell potential.	Poor: poorly drained.	Unsuited	Poor: poorly drained.

TABLE 7.—*Interpretations*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basement
Gravel pits: Gp. No interpretations made; properties too variable; onsite investigation needed.				
Great Bend: GrA	Moderate: moderate permeability.	Slight	Slight	Moderate: moderate shrink-swell potential.
Hamerly: HaA, HbA. For Tonka part of HbA, see that series.	Severe: seasonal high water table; moderately slow permeability.	Slight	Moderate: moderately well drained.	Moderate if water table is below a depth of 30 inches: moderately well drained; moderate shrink-swell potential. Severe if water table is above a depth of 30 inches.
Hamlet: HhA, HmA. For Hamerly part of HhA and for Tonka parts of HhA and HmA, see those series.	Severe: slow permeability.	Slight if slope is less than 3 percent. Moderate if slope is 3 to 6 percent.	Moderate: moderately well drained.	Moderate: moderately well drained; moderate shrink-swell potential.
Hecla: HoA. For Lohnes part, see that series.	Slight	Severe: rapid permeability.	Severe: loamy sand.	Moderate: moderately well drained.
LaDelle: LaA	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: occasional to frequent flooding.
Lohnes: LoB	Slight	Severe: rapid permeability.	Severe: loamy sand.	Slight
Ludden: Lu, Ly	Severe: slow permeability; poorly drained.	Severe: subject to flooding.	Severe: poorly drained; clay.	Severe: poorly drained; subject to flooding; high shrink-swell potential.
Marsh: Ma. No interpretations made; properties too variable; onsite investigation needed.				
Marysland: Mb	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained.	Severe: poorly drained.
Max	Severe: moderately slow permeability; steep.	Severe if slope is more than 9 percent.	Moderate if slope is 9 to 15 percent. Severe if slope is more than 15 percent.	Moderate if slope is less than 15 percent: moderate shrink-swell potential. Severe if slope is more than 15 percent.

See footnote at end of table.

of engineering properties—Continued

Degree and kind of limitation for—Continued			Suitability as source of—		
Dwellings without basement	Sanitary landfill [1] (trench type)	Roads and streets	Road fill	Sand and gravel	Topsoil
Severe: high frost action potential.	Moderate: silty clay loam.	Severe: high frost action potential.	Poor: high frost action potential.	Unsuited	Fair: 8 to 16 inches of material; silty clay loam.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Severe: water table.	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Fair: 8 to 16 inches of material.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Slight	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Fair: 8 to 16 inches of material.
Slight	Severe: rapid permeability.	Slight	Good	Fair for sand only	Poor: loamy sand.
Severe: occasional to frequent flooding; high frost action potential.	Severe: subject to flooding.	Severe: high frost action potential.	Poor: high frost action potential.	Unsuited	Fair: silty clay loam.
Slight	Severe: rapid permeability.	Slight	Good	Fair for sand only	Poor: loamy sand.
Severe: poorly drained; subject to flooding; high shrink-swell potential.	Severe: poorly drained; subject to flooding; clay.	Severe: poorly drained; high shrink-swell potential.	Poor: high shrink-swell potential.	Unsuited	Poor: poorly drained; silty clay.
Severe: poorly drained.	Severe: water table; poorly drained.	Severe: poorly drained.	Poor: poorly drained.	Fair: water table	Poor: poorly drained.
Moderate if slope is less than 15 percent: moderate frost action potential; moderate shrink-swell potential. Severe if slope is more than 15 percent.	Slight if slope is less than 15 percent. Moderate if slope is 15 to 25 percent. Severe if slope is more than 25 percent.	Moderate if slope is less than 15 percent: moderate frost action potential; moderate shrink-swell potential. Severe if slope is more than 15 percent.	Fair if slope is less than 25 percent: moderate frost action potential; moderate shrink-swell potential. Severe if slope is more than 25 percent.	Unsuited	Fair if slope is less than 15 percent: 8 to 16 inches of material. Poor if slope is more than 15 percent.

TABLE 7.—*Interpretations*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basement
Parnell: Pa	Severe: slow permeability; very poorly drained.	Severe: seasonal high water table.	Severe: very poorly drained.	Severe: very poorly drained.
Renshaw: RnA, RnB	Slight: very rapid permeability; hazard of pollution.	Severe: very rapid permeability.	Severe: very gravelly material.	Slight
Sioux: SoB, SoD	Slight: very rapid permeability; hazard of pollution.	Severe: very rapid permeability.	Severe: very gravelly material.	Slight if slope is less than 9 percent. Moderate if slope is 9 to 15 percent. Severe if slope is more than 15 percent.
Svea: SvA, SvB, SwB, SyA, SyB	Severe: moderately slow permeability.	Slight if slope is less than 3 percent. Moderate if slope is 3 to 6 percent.	Moderate: moderately well drained.	Moderate: moderately well drained; moderate shrink-swell potential.
Swenoda: SzA, SzB	Severe: moderately slow permeability.	Slight if slope is less than 3 percent. Moderate if slope is 3 to 6 percent.	Moderate: moderately well drained.	Moderate: moderately well drained; moderate shrink-swell potential.
Tiffany: Tf	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained.	Severe: poorly drained.
Tonka: To	Severe: slow permeability; poorly drained.	Severe: subject to flooding and ponding.	Severe: poorly drained; clay.	Severe: poorly drained; subject to flooding; high shrink-swell potential.
Vallers: Va	Severe: poorly drained; seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained.	Severe: poorly drained.
Velva: Vb, Vd	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: occasional to frequent flooding.
Williams: WmA, WmB	Moderate to severe: moderately slow permeability.	Slight if slope is less than 3 percent. Moderate if slope is 3 to 6 percent.	Slight	Moderate: moderate shrink-swell potential.
Wyndmere: WyA	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.

See footnote at end of table.

of engineering properties—Continued

Degree and kind of limitation for—Continued			Suitability as source of—		
Dwellings without basement	Sanitary landfill [1] (trench type)	Roads and streets	Road fill	Sand and gravel	Topsoil
Severe: very poorly drained.	Severe: water table; very poorly drained.	Severe: very poorly drained.	Poor: very poorly drained.	Unsuited	Poor: very poorly drained.
Slight	Severe: very rapid permeability; soil texture.	Slight	Good	Fair	Fair: 8 to 16 inches of material.
Slight if slope is less than 9 percent. Moderate if slope is 9 to 15 percent. Severe if slope is more than 15 percent.	Severe: very rapid permeability; soil texture.	Slight if slope is less than 9 percent. Moderate if slope is 9 to 15 percent. Severe if slope is more than 15 percent.	Good	Fair	Poor: material too thin.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Slight	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Good.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Slight	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Good.
Severe: poorly drained.	Severe: water table.	Severe: poorly drained.	Severe: poorly drained.	Poor for sand only.	Good.
Severe: poorly drained; subject to flooding; high shrink-swell potential.	Severe: poorly drained; subject to flooding; clay.	Severe: poorly drained; high shrink-swell potential.	Poor: poorly drained.	Unsuited	Poor: poorly drained.
Severe: poorly drained.	Severe: water table; poorly drained.	Severe: poorly drained.	Poor: poorly drained.	Unsuited	Poor: poorly drained.
Severe: occasional to frequent flooding.	Severe: subject to flooding.	Moderate: moderate frost action potential; occasional to frequent flooding.	Fair: moderate frost action potential.	Unsuited	Fair: 8 to 16 inches of material.
Moderate: moderate frost action potential; moderate shrink-swell potential.	Slight	Moderate: moderate frost action potential; moderate shrink-swell potential.	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuited	Fair: 8 to 16 inches of material.
Moderate: moderate frost action potential; somewhat poorly drained.	Severe: water table.	Moderate: moderate frost action potential; somewhat poorly drained.	Fair: moderate frost action potential; somewhat poorly drained.	Poor for sand only: water table.	Fair: 8 to 16 inches of material.

TABLE 7.—*Interpretations*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basement
Zahl: ZaD, ZaF For Max parts, see that series.	Severe: moderately slow permeability; steep.	Severe if slope is more than 9 percent.	Moderate if slope is 9 to 15 percent. Severe if slope is more than 15 percent.	Moderate if slope is less than 15 percent: moderate shrink-swell potential. Severe if slope is more than 15 percent.

[1] Onsite deep studies of the underlying strata, water table, and hazards of aquifer pollution and drainage into ground water need to be made for landfills of more than 5 or 6 feet.

In table 7 soil suitability is rated by the terms *good, fair,* and *poor,* which have meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of some of the columns in table 7.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material between depths of 18 inches and 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic matter, and slope. If the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified soil classification and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet; for example, excavations for pipelines, sewerlines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Dwellings are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Trench-type sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the limitations in table 7 apply only to a depth of about 6 feet; therefore, limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 or 15 feet, but regardless of that, every site should be investigated before it is selected.

Roads and streets have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity, stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material and the shrink-swell potential indicate the traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

of engineering properties—Continued

Degree and kind of limitation for—Continued			Suitability as source of—		
Dwellings—Con. without basement	Sanitary landfill [1] (trench type)	Roads and streets	Road fill	Sand and gravel	Topsoil
Moderate if slope is less than 15 percent: moderate frost action potential; moderate shrink-swell potential. Severe if slope is more than 15 percent.	Slight if slope is less than 15 percent. Moderate if slope is 15 to 25 percent. Severe if slope is more than 25 percent.	Moderate if slope is less than 15 percent: moderate frost action potential; moderate shrink-swell potential. Severe if slope is more than 15 percent.	Fair if slope is less than 25 percent: moderate frost action potential; moderate shrink-swell potential. Poor if slope is more than 25 percent.	Unsuited	Poor: material too thin.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 7 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials or the quality of the deposit.

Topsoil is used for topdressing an area where plants are to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and the content of stone fragments are characteristics that affect suitability. Also considered in the ratings is damage that can result at the area from which topsoil is taken.

Following are explanations of some of the columns in table 8.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material in a soil are among the unfavorable factors.

Drainage is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; and depth of root zone. It is also affected by the rate of water intake at the surface, permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water, amount of water held available to plants, and need for drainage or depth to water table or bedrock.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope, depth to bedrock or other unfavorable material, presence of stones, permeability, and resistance to erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff, and establishing a plant cover is not difficult.

Grassed waterways are natural or constructed waterways that are seeded to grass as protection against erosion. Features that affect the suitability of the soil for grassed waterways are those that affect the establishment, growth, and maintenance of plants or that hinder the layout and construction of the waterway.

Formation and Classification of the Soils

This section describes the factors of soil formation and shows the classification of the soils in Renville County by higher categories.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are

TABLE 8.—*Soil features affecting land uses*

Soil series and map symbols	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Arveson: Ar	Rapid permeability; water table.	Good to poor stability; fair compaction characteristics; moderate to rapid permeability; poor resistance to piping.	Water table; may not have outlets available.	Poorly drained; moderately rapid permeability; moderate available water capacity.	Not needed	Not needed.
Arvilla: AvC, AwA, AwB. For Sioux part of AwA and AwB, see that series.	Very rapid permeability.	Good stability; fair to good compaction characteristics; moderate permeability.	Not needed	Moderately rapid permeability over very rapid permeability; low available water capacity.	Less than 20 inches to gravel and sand; hazard of erosion.	Sandy loam; hazard of erosion; less than 20 inches to gravel and sand; low available water capacity.
Barnes: BaA, BaB, BaC, BaD, BbB, BdB, BdC, BfA, BgB, BhA, BhB, BnD. For Buse part of BdB, BdC, and BnD, Cresbard part of BfA, Hamerly part of BgB, Hamlet part of BhA and BhB, and for Tonka part of BhA and BhD, see those series.	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility.	Not needed	Moderately slow permeability; some steep, complex slopes.	Short, complex slopes; steep.	All features favorable, except on steep slopes.
Buse	Slope	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed	Moderate permeability; complex slopes.	Short, complex slopes; moderate permeability; steep.	Steep; thin surface layer.
Cavour: CaA. For Cresbard part, see that series.	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed	Very slow permeability; moderate available water capacity; salinity.	Not needed	Not needed.
Colvin: Co, Cp, Cr	Water table; suitable for dugouts; moderately slow permeability.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Water table; may not have outlets available.	Poorly drained; moderately low permeability.	Not needed	Not needed.

TABLE 8.—*Soil features affecting land uses*—Continued

Soil series and map symbols	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Cresbard	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed	Moderately slow permeability.	Not needed	Not needed.
Divide: DdA	Water table; suitable for dugouts; very rapid permeability.	Good stability; fair to good compaction characteristics; low to moderate permeability; medium compressibility; fair resistance to piping.	Water table; may not have outlets available.	Water table; moderate permeability over very rapid permeability; low available water capacity; moderately slow permeability below a depth of 40 inches.	Not needed	Not needed.
Embden: EmB, EoA. For Tiffany part of EoA, see that series.	Moderately rapid to rapid permeability.	Good stability; fair to good compaction characteristics; moderate permeability; slight compressibility; poor resistance to piping.	Not needed	Moderately rapid permeability; moderate available water capacity.	Complex slopes; hazard of erosion.	Fine sandy loam; hazard of erosion.
Fargo: Fa, Fb	All features favorable.	Fair to poor stability; fair to poor compaction characteristics; high compressibility.	Areas of surface ponding; slow permeability.	Slow permeability; surface ponding.	Not needed	Not needed.
Fulda: Fu	All features favorable.	Fair stability; fair compaction characteristics; high compressibility.	May not have outlets available; surface ponding; slow permeability.	Slow permeability; surface ponding.	Not needed	Not needed.
Gravel pits: Gp. No interpretations made; properties too variable; onsite investigation needed.						
Great Bend: GrA	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility.	Not needed	Moderately slow permeability.	Moderate permeability.	Not needed.

TABLE 8.—*Soil features affecting land uses*—Continued

Soil series and map symbols	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Hamerly: HaA, HbA—For Tonka part of HbA, see that series.	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility.	Seasonal high water table.	Moderately slow permeability.	Not needed	All features favorable.
Hamlet: HhA, HmA—For Hamerly part of HhA and for Tonka part of HhA and HmA, see those series.	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility.	Not needed	Slow permeability.	Not needed	All features favorable.
Hecla: HoA—For Lohnes part, see that series.	Rapid permeability.	Good to poor stability; fair compaction characteristics; moderate to high permeability; poor resistance to piping.	Not needed	Rapid permeability; low available water capacity.	Loamy sand; rapid permeability; hazard of erosion.	Loamy sand; hazard of erosion; low available water capacity.
LaDelle: LaA	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed; flooding caused by stream overflow.	Susceptible to stream overflow.	Not needed	All features favorable.
Lohnes: LoB	Rapid permeability.	Fair stability; fair compaction characteristics; high permeability; fair resistance to piping.	Not needed	Rapid permeability; low available water capacity.	Loamy sand; rapid permeability; hazard of erosion.	Loamy sand; hazard of erosion; low available water capacity.
Ludden: Lu, Ly	All features favorable.	Fair to poor stability; fair to poor compaction characteristics; high compressibility.	Surface ponding; slow permeability.	Slow permeability; susceptible to stream overflow.	Not needed	Not needed.
Marsh: Ma. No interpretations made; properties too variable; on-site investigation needed.						
Marysland: Mb	Water table; suitable for dugouts; very rapid permeability.	Good stability; fair to good compaction characteristics; moderate permeability; slight compressibility; fair to poor resistance to piping.	Water table; may not have outlets available.	Poorly drained; moderate permeability over very rapid permeability; moderate available water capacity.	Not needed	Not needed.

TABLE 8.—*Soil features affecting land uses*—Continued

Soil series and map symbols	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Max	Slope	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed	Moderately slow permeability; steep.	Moderately slow permeability; steep, complex slopes; hazard of erosion.	Steep.
Parnell: Pa	Water table	Fair stability; fair compaction characteristics; low permeability; high compressibility; good resistance to piping.	Water table; may not have outlets available; surface ponding.	Very poorly drained; slow permeability.	Not needed	Not needed.
Renshaw: RnA, RnB	Very rapid permeability.	Good stability; fair to good compaction characteristics; moderate permeability; slight compressibility; poor resistance to piping.	Not needed	Moderate permeability over very rapid permeability; moderate available water capacity.	Less than 20 inches to gravel and sand.	Less than 20 inches to gravel and sand; moderate available water capacity.
Sioux: SoB, SoD	Very rapid permeability.	Good stability; fair to good compaction characteristics; moderate permeability; slight compressibility; poor resistance to piping.	Not needed	Very rapid permeability; very low available water capacity; steep.	Less than 10 inches to gravel and sand.	Less than 10 inches to gravel and sand; very low available water capacity.
Svea: SvA, SvB, SwB, SyA, SyB.	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility.	Not needed	Moderately slow permeability.	All features favorable.	All features favorable.
Swenoda: SzA, SzB	Moderately rapid permeability over moderately slow permeability.	Good stability; fair to good compaction characteristics; moderate to low permeability; slight to high compressibility; poor resistance to piping in upper 23 inches.	Not needed	Moderately rapid permeability over moderately slow permeability; moderate available water capacity.	Moderately rapid permeability over moderately slow permeability; short slopes.	Fine sandy loam; hazard of erosion.

TABLE 8.—*Soil features affecting land uses*—Continued

Soil series and map symbols	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Tiffany: Tf	Seasonal high water table.	Good stability; fair to good compaction characteristics; moderate to low permeability; slight to high compressibility; poor resistance to piping in upper 46 inches.	Water table; may not have outlets available.	Poorly drained; moderate permeability; moderate available water capacity.	Not needed	Fine sandy loam; hazard of erosion.
Tonka: To	All features favorable.	Fair to good stability; fair to good compaction characteristics; medium to high compressibility.	May not have outlets available; surface ponding; slow permeability.	Slow permeability; surface ponding.	Not needed	Not needed.
Vallers: Va	Water table	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Water table; may not have outlets available.	Poorly drained; moderately slow permeability.	Not needed	Not needed.
Velva: Vb, Vd	Moderate permeability to moderately rapid permeability.	Poor stability; poor compaction characteristics; moderate permeability; medium compressibility; poor resistance to piping.	Not needed; flooding caused by stream overflow.	Susceptible to stream overflow.	Not needed	All features favorable.
Williams: WmA, WmB	All features favorable.	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility.	Not needed	Moderately slow permeability.	Short, complex slopes; moderately slow permeability.	All features favorable.
Wyndmere: WyA	Water table; moderately rapid permeability.	Good stability; fair to good compaction characteristics; moderate permeability; slight compressibility; poor resistance to piping.	Water table; may not have outlets available.	Somewhat poorly drained; moderately rapid permeability; moderate available water capacity.	Not needed	Not needed.
Zahl: ZaD, ZaF For Max part, see that series.	Slope	Fair to good stability; fair to good compaction characteristics; low permeability; medium to high compressibility; good resistance to piping.	Not needed	Moderately slow permeability; steep.	Steep, complex slopes; moderately slow permeability.	Steep; thin surface layer.

determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effect of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effect on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

Parent material

All the soils in Renville County formed in glacial material derived from preglacial rocks consisting of granite, gneiss, sandstone, shale, limestone, and basalt. The glacier picked up these materials, ground and mixed them as it transported them across country, and then deposited them as it melted. Some deposits consist of unsorted material or glacial till; others consist of material sorted either by water while it was deposited or by wind and water afterward.

Climate

Renville County has a cool, dry-subhumid, continental climate characterized by long, cold winters and a short growing season, during which the distribution of rainfall is erratic. The climate does not vary much from place to place in the county and probably has not changed much during the period of soil formation. It has been favorable for the growth of prairie vegetation.

Temperature and moisture affect the growth of plants, the activity of micro-organisms, and the speed of chemical reactions, particularly during the growing season. Rainfall has not been sufficient for the deep leaching of the soils, nor has it caused more than a small amount of erosion. Freezing and thawing help to disintegrate parts of the glacial debris, and frost heaving helps to mix soil materials, thus affecting soil structure. The cool temperatures slow the decay of plant and animal materials, thus promoting the accumulation of organic matter. This process is responsible for the large amount of organic matter in Svea and Hamlet soils. In these ways climate has had an effect on soil formation in this county.

Plant and animal life

Soil formation started in Renville County when plants began to grow in the unconsolidated material deposited by the glacier. Well-drained soils formed under predominantly cool-season, drought-resistant grasses. Tall, warm-season grasses grow where the soils receive extra moisture.

Plant roots loosen the soil material and bring minerals from the parent material upward toward the surface. As the plants die and decay, they contribute organic matter, and bacteria and other micro-organisms help to decompose the organic matter. Thus, nutrients leached out of the surface layer are replaced, and a good supply is maintained for growth of other plants.

The activity of animals seems to be of less importance to soil formation in this county than the growth of plants. Earthworms and burrowing animals help to mix the soil material from various horizons and bring some fresh parent material to the surface layer. The activities of man, particularly in altering drainage, maintaining fertility, and changing the kinds of vegetation, have an important effect on both the rate and the direction of soil formation.

Relief

Relief influences the formation of soils through its effect on runoff and drainage. If other soil-forming factors are equal, relief largely determines the degree of profile development, mainly because it controls the amount of moisture in the soil. Because of excessive drainage, only a little water is held in the more sloping and coarser textured soils, and vegetation is sparse; consequently, profile development is slow. Among the soils affected in this way are Buse, Zahl, and Sioux soils. Excessive water in areas that have poor drainage also affects the process of soil formation. Examples of soils affected by poor drainage are Parnell, Fulda, and Tonka soils.

Time

Time is necessary for the factors of soil formation to act on parent material. Generally, length of time determines whether the soil has reached an equilibrium with its environment.

The degree of profile development in most of the soils in Renville County has been affected more by other differences than by the length of time because, except for the Velva, Ludden, and LaDelle soils, the length of time has been about the same. In terms of geologic time, the soils are young because they formed from material deposited in late Pleistocene time, which ended about 11,000 years ago.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad

classes to facilitate study and comparison in large areas, such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because the system is under continual study, readers interested in developments of the current system should search the latest literature available (*3, 5*).

The current system of classification has six categories. Beginning with the broadest, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. In table 9, the soil series of the county are placed in categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

Order.—Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. Each order is named with a word of three or four syllables, ending in *sol*. An example is *Entisol*.

Suborder.—Each order is divided into suborders, based mainly on those soil characteristics that seem to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the order. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging, or soil differences that result from the climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is *Aquent* (*Aqu*, meaning water or wet; and *ent*, from Entisol).

Great group.—Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus has accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark-colored surface horizons. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark-red and dark-brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is *Haplaquents* (*Hapl*, meaning simple horizons; *aqu*, for wetness or water; and *ent*, from Entisols).

Subgroup.—Great groups are divided into subgroups, one that represents the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside the range of any great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives in front of the name of the great group. An example is *Typic Haplaquents* (a typical Haplaquent).

TABLE 9.—*Classification of the soils*

Soil series	Family	Subgroup	Order
Arveson	Coarse-loamy, frigid	Typic Calciaquolls	Mollisols.
Arvilla	Sandy, mixed	Udic Haploborolls	Mollisols.
Barnes	Fine-loamy, mixed	Udic Haploborolls	Mollisols.
Buse	Fine-loamy, mixed	Udorthentic Haploborolls	Mollisols.
Cavour	Fine, mixed	Udic Natriborolls	Mollisols.
Colvin	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Cresbard	Fine-mixed	Glossic Udic Natriborolls	Mollisols.
Divide	Fine-loamy over sandy or sandy-skeletal, frigid	Aeric Calciaquolls	Mollisols.
Embden	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Fargo	Fine, montmorillonitic, noncalcareous, frigid	Vertic Haplaquolls	Mollisols.
Fulda	Fine, montmorillonitic, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Great Bend	Fine-silty, mixed	Udic Haploborolls	Mollisols.
Hamerly	Fine-loamy, frigid	Aeric Calciaquolls	Mollisols.
Hamlet	Fine-loamy, mixed	Aquic Haploborolls	Mollisols.
Hecla	Sandy, mixed	Pachic Udic Haploborolls	Mollisols.
La Delle	Fine-silty, mixed	Cumulic Udic Haploborolls	Mollisols.
Lohnes	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Ludden	Fine, montmorillonitic, calcareous, frigid	Vertic Haplaquolls	Mollisols.
Marysland	Fine-loamy over sandy or sandy-skeletal, frigid	Typic Calciaquolls	Mollisols.
Max	Fine-loamy, mixed	Typic Haploborolls	Mollisols.
Parnell	Fine, montmorillonitic, frigid	Typic Argiaquolls	Mollisols.
Renshaw	Fine-loamy over sandy or sandy-skeletal, mixed	Udic Haploborolls	Mollisols.
Sioux	Sandy-skeletal, mixed	Udorthentic Haploborolls	Mollisols.
Svea	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Swenoda	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Tiffany	Coarse-loamy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Tonka	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Vallers	Fine-loamy, frigid	Typic Calciaquolls	Mollisols.
Velva	Coarse-loamy, mixed	Fluventic Haploborolls	Mollisols.
Williams	Fine-loamy, mixed	Typic Argiborolls	Mollisols.
Wyndmere	Coarse-loamy, frigid	Aeric Calciaquolls	Mollisols.
Zahl	Fine-loamy, mixed	Entic Haploborolls	Mollisols.

Family.—Soil families are established within a subgroup mainly on the basis of properties important to the growth of plants or on the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used to differentiate families. An example is the coarse-loamy, siliceous, acid, thermic family of Typic Haplaquents.

General Nature of the County

Renville County was first inhabited by Chippewa and Assiniboine Indians. It was next visited by French and English traders and hunters. It was permanently settled in the late 1800's.

The two main rivers of the county are the Souris River, which enters near the extreme northwest corner from Canada and is the source of water for Lake Darling, and the Des Lacs River, which crosses the southwest corner of the county. The Des Lacs River is a tributary of the Souris, entering it near Burlington in Ward County. All of Renville County is within the Souris River drainage system. The drainageways extend in a southeastward direction. The elevation is 1,647 feet at Sherwood; 1,631 feet at Loraine; 1,646 feet at Mohall; and 1,575 feet at Glenburn.

The population reached a peak of 7,263 people in 1930 and gradually declined to 3,828 by 1970. In 1971 Renville County had 660 farms. The average farm was 850 acres.

The main field crops are durum wheat, spring wheat, barley, flax, oats, and rye. According to the annual summary for 1970, published by the North Dakota Crop and Livestock Statistics, 133,000 acres were seeded to wheat, 36,100 acres to durum wheat; 32,000 acres to barley; 30,000 acres to flax; 36,000 acres to oats; and 5,000 acres to rye. Approximately 94 percent of the wheat and 44 percent of the barley were seeded in fields that had been summer fallowed.

Raising livestock, mostly beef cattle, is the second most important farming enterprise. In 1969, about 17,000 acres of alfalfa, tame, and wild hay was harvested. Most beef herds are of the cow-calf type. Hereford, Aberdeen Angus, and Shorthorn are the most common breeds. There are few dairy herds in the county.

Physiography, Relief, and Drainage

Most of Renville County is nearly level. Very steep soils are on the breaks of the Souris and Des Lacs Rivers. Several drainage channels flow in a southeasterly direction through the county, but most of the drainage goes into thousands of depressions in the till plains.

Relief affects runoff and drainage. Runoff is rapid on steep soils and slow on level ones. There is more runoff from convex slopes than from concave ones. Where runoff is rapid, less water enters the soil, plant growth is limited, soil formation is slow, and soil horizons are usually thin. Buse and Zahl soils are good examples.

Runoff from surrounding areas provides extra moisture for the growth of plants in depressions and swales. Wet areas have a thick, dark-colored, highly organic surface layer. The wetness causes slow or incomplete decay of organic matter. A good example of this is Parnell silty clay loam. Soils that have a high water table in many places have a zone that is high in content of lime near the surface. Colvin and Marysland soils are examples.

Climate [6]

Renville County has a continental climate. The summers are pleasantly warm, and the winters are long and cold. In winter there are usually several mild periods when temperatures are above freezing. Temperature and precipitation data are shown in table 10. About 85 percent of the precipitation falls during the warm season of April to October.

The passage of fronts is common throughout the year, and several large and rapid fluctuations in temperature often occur within a period of a week or two. The normal daily range in temperature is about 21 degrees in midwinter and about 29 degrees during summer, but the passage of a front can cause a temperature change of 40 to 50 degrees in 24 hours. In the period of record for Mohall, maximum temperatures have been as high as 108° F and minimum temperatures have been as low as 44° below zero, a range of 152° F for a period of 40 years.

In an average year, maximum temperatures equal to or more than 90° occur on about 17 days, about 75 percent of which occur in July and August. The likelihood of a period of 5 or more successive days when temperatures are higher than 90° is greatest during the last 2 weeks of July, but the chance is less than 10 percent. Minimum temperatures are freezing or below on about 200 days during the year. Temperatures of zero or below occur on 59 days in an average year. Probabilities of freezing temperatures are shown in table 11.

The average length of the freeze-free period ranges from about 110 days in the eastern part of the county to slightly more than 120 days in the southwestern part. No time of the year can be considered absolutely frost free or freeze free. In the 40-year record at Mohall, freezing temperatures have occurred in every month except July, when a low of 35° F has been recorded.

Average annual precipitation in Mohall for the years 1930 65 was 16.77 inches. Precipitation in the county ranges from about 15 inches in the extreme southwestern part to almost 17 inches in the extreme northeastern part. Annual rainfall at Mohall has ranged from 7.98 inches to 25.87 inches. Normally, there are 75 days when 0.01 inch or more of precipitation is received. Rainfall of 1.0 inch in 30 minutes, 1.4 inches in 1 hour, and 1.9 inches in 24 hours can be expected once every 2 years. Thunderstorms occur about 30 times a year. The percentage probability of receiving specified amounts of precipitation during various periods of the growing season at Bottineau is shown in table 12. The percentage probabilities for Renville County should range about 2 percent lower than at Bottineau.

[6] By Ray Jensen, climatologist, National Weather Service, U.S. Department of Commerce.

TABLE 10.—*Temperature and precipitation data*

[All data from Mohall for the period 1930–65]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average highest maximum	Average lowest minimum	Average total	One year in 10 will have -		Days that have snow cover	Average depth of snow on days that have snow cover
						Less than—	More than—		
	°F	°F	°F	°F	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	15.8	−5.1	39.9	−28.8	0.42	0.1	0.8	28	7.7
February	20.1	−0.8	43.0	−25.4	.46	.1	1.1	25	9.0
March	32.0	11.6	54.7	−13.7	.73	.1	1.5	21	7.8
April	52.5	28.4	77.1	10.8	1.20	.1	2.0	4	3.9
May	67.2	39.9	88.5	24.8	2.20	.5	3.6	1	(1)
June	75.1	49.6	93.2	35.6	3.88	1.3	6.5	0	(1)
July	83.1	55.0	97.0	42.2	2.43	.5	4.4	0	(1)
August	81.6	52.5	97.2	39.0	2.14	.6	4.0	0	(1)
September	70.3	41.3	91.6	24.8	1.47	.1	4.8	0	(1)
October	58.3	31.3	81.0	13.0	.87	[2] T	2.5	1	2.3
November	36.3	15.6	59.6	−9.1	.55	T	1.1	11	2.1
December	22.7	3.2	45.6	−22.8	.42	T	.8	24	4.0
Year	51.3	26.9	[3] 99.9	[4] −31.4	16.77	9.5	23.2	115	7.3

[1] Less than 1 inch.
[2] Trace.
[3] Average annual highest temperature.
[4] Average annual lowest temperature.

TABLE 11.—*Probability of last freezing temperature in spring and first in fall*

[All data from the station at Mohall]

Probability	Dates for given probability and temperature				
	32° F	28° F	24° F	20° F	16° F
Spring:					
1 year in 10 later than	June 8	May 22	May 14	May 7	April 29
1 year in 4 later than	June 1	May 15	May 6	April 30	April 21
1 year in 2 later than	May 25	May 8	April 28	April 21	April 12
3 years in 4 later than	May 18	May 1	April 20	April 13	April 3
9 years in 10 later than	May 11	April 24	April 12	April 5	March 26
Fall:					
1 year in 10 earlier than	September 3	September 10	September 17	September 28	October 7
1 year in 4 earlier than	September 9	September 16	September 25	October 6	October 15
1 year in 2 earlier than	September 15	September 23	October 3	October 15	October 24
3 years in 4 earlier than	September 21	September 30	October 11	October 24	November 2
9 years in 10 earlier than	September 27	October 6	October 19	November 1	November 10

Hail can be expected on about 2 days per year in the part of Renville County that borders McHenry County to about 3 days per year in the northwestern part of the county. July and August are the main months for hail activity.

The average annual snowfall is about 31 inches. Annual amounts have ranged from only 3 inches in the winter of 1930–31 to 63 inches in 1949–50. Average snowfall for the months November to March is 5 to 7 inches. Snowfall of 0.1 inch or more occurs 1 year in 7 in September, 1 year in 2 in October, and 1 year in 5 in May. Nearly every year, blizzards occur and blowing snow (ground blizzards) restricts visibility several times each winter.

The annual evaporation from a Weather Bureau Class A pan averages about 45 inches. Of this, 84 percent occurs in the period May to October. The annual evaporation from lakes averages 34 inches.

Renville County receives 61 percent of possible annual sunshine. July, averaging 74 percent of the possible sunshine, is the sunniest month. November and December, which have about 45 percent of the possible sunshine, are the cloudiest months.

The prevailing wind direction in Renville County is northwesterly, but in May to August it is southeasterly. April is the windiest month.

Soil blowing and water erosion are probably the most serious concerns of management associated with most soils in the county. Soil blowing is generally most severe in March and April.

TABLE 12.—*Probability of precipitation during the growing season*

[All data are for Bottineau. Absence of data means that the probability is less than 10 percent]

Growing season	Probability in percent for receiving precipitation of—						
	Less than 4 inches	4 inches	6 inches	8 inches	10 inches	12 inches	14 inches
77-day period:							
March 15 to May 30	70	30					
March 22 to June 6	65	35					
March 29 to June 13	55	45	15				
April 5 to June 20	40	60	30				
April 12 to June 27	25	75	40	15			
April 19 to July 4	20	80	50	20			
April 26 to July 11	15	85	55	25	10		
May 3 to July 18	15	85	55	30	10		
May 10 to July 25	10	90	60	30	10		
May 17 to August 1	10	90	60	30	10		
May 24 to August 8	10	90	60	35	15		
May 31 to August 15	10	90	65	35	15		
June 7 to August 22	10	90	60	35	15		
June 14 to August 29	10	90	60	30	10		
91-day period:							
March 15 to June 13	45	55	20				
March 22 to June 20	35	65	30	10			
March 29 to June 27	20	80	45	20			
April 5 to July 4	15	85	55	25	10		
April 12 to July 11	10	90	60	30	15		
April 19 to July 18	10	90	65	40	20		
April 26 to July 25	5	95	70	40	20		
May 3 to August 1	5	95	70	40	20		
May 10 to August 8	5	95	70	45	25	10	
May 17 to August 15	5	95	80	50	25	10	
May 24 to August 22	5	95	80	50	25	10	
May 31 to August 29	5	95	80	50	25		
June 7 to September 5	5	95	80	50	20		
June 14 to September 12	5	95	75	45	20		
119-day period:							
April 26 to August 22	1	99	90	70	45	25	10
May 3 to August 29	1	99	90	70	45	25	10
May 10 to September 5	1	99	90	70	45	25	10
May 17 to September 12	1	99	90	70	45	25	10
May 24 to September 19	1	99	90	70	45	20	10
May 31 to September 26	1	99	90	70	40	20	

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low available water capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay sesquioxides humus or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher.
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles) adhering together without any regular cleavage, as in many claypans and hardpans.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a capability unit, read the introduction to the section it is in for general information about its management.

Map symbol	Mapping unit	Page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
Ar	Arveson loam	6	IIIw-5	38	2	43
AvC	Arvilla sandy loam, 6 to 9 percent slopes	6	IIIes-3	38	6	43
AwA	Arvilla-Sioux sandy loams, 1 to 3 percent slopes	7	IIIes-3	38	--	--
	Arvilla part	7	-------	--	6	43
	Sioux part	7	-------	--	10	44
AwB	Arvilla-Sioux sandy loams, 3 to 6 percent slopes	7	IIIes-3	38	--	--
	Arvilla part	7	-------	--	6	43
	Sioux part	7	-------	--	10	44
BaA	Barnes loam, 1 to 3 percent slopes	8	IIc-6	37	3	43
BaB	Barnes loam, 3 to 6 percent slopes	8	IIe-6	35	3	43
BaC	Barnes loam, 6 to 9 percent slopes	8	IIIe-6	37	3	43
BaD	Barnes loam, 9 to 12 percent slopes	8	IVe-6	39	10	44
BbB	Barnes cobbly loam, 1 to 6 percent slopes	8	IIe-6	35	3	43
BdB	Barnes-Buse loams, 3 to 6 percent slopes	9	IVe-4L	39	--	--
	Barnes part	9	-------	--	3	43
	Buse part	9	-------	--	8	43
BdC	Barnes-Buse loams, 6 to 9 percent slopes	9	IVe-4L	39	--	--
	Barnes part	9	-------	--	3	43
	Buse part	9	-------	--	8	43
BfA	Barnes-Cresbard loams, 1 to 3 percent slopes	9	IIIs-6P	39	--	--
	Barnes part	9	-------	--	3	43
	Cresbard part	9	-------	--	4	43
BgB	Barnes-Hamerly loams, 3 to 6 percent slopes	10	IIe-6	35	--	--
	Barnes part	10	-------	--	3	43
	Hamerly part	10	-------	--	1	43
BhA	Barnes-Hamlet-Tonka loams, 1 to 3 percent slopes	10	IIc-6	37	--	--
	Barnes part	10	-------	--	3	43
	Hamlet part	10	-------	--	1	43
	Tonka part	10	-------	--	2	43
BhB	Barnes-Hamlet-Tonka loams, 3 to 6 percent slopes	10	IIe-6	35	--	--
	Barnes part	10	-------	--	3	43
	Hamlet part	10	-------	--	1	43
	Tonka part	10	-------	--	2	43
BnD	Barnes and Buse very stony loams, 3 to 15 percent slopes	11	VIIs-6	40	10	44
CaA	Cavour-Cresbard loams, 1 to 3 percent slopes	12	IVs-6P	39	--	--
	Cavour part	12	-------	--	9	43
	Cresbard part	12	-------	--	4	43
Co	Colvin silt loam	13	IIw-4L	37	2	43
Cp	Colvin soils, channeled	13	Vw-4	40	10	44
Cr	Colvin soils, very wet	13	Vw-4	40	10	44
DdA	Divide loam, loamy substratum, 1 to 3 percent slopes	15	IIIs-4L	38	1	43
EmB	Embden sandy loam, 1 to 6 percent slopes	15	IIIe-3	37	1	43
EoA	Embden-Tiffany fine sandy loams, 1 to 3 percent slopes	15	IIIe-3	37	--	--
	Embden part	15	-------	--	1	43
	Tiffany part	15	-------	--	2	43
Fa	Fargo silty clay	16	IIw-4	37	1	43
Fb	Fargo silty clay, very wet	16	Vw-4	40	10	44
Fu	Fulda silty clay loam	16	IIIw-6	38	2	43
Gp	Gravel pits	17	VIIIs-1	40	10	44
GrA	Great Bend silty clay loam, 1 to 3 percent slopes	17	IIc-6	37	1	43
HaA	Hamerly loam, 1 to 3 percent slopes	18	IIe-4L	35	1	43
HbA	Hamerly-Tonka loams, 1 to 3 percent slopes	18	IIe-4L	35	--	--
	Hamerly part	18	-------	--	1	43
	Tonka part	18	-------	--	2	43

GUIDE TO MAPPING UNIT--Continued

Map symbol	Mapping unit	Page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
HhA	Hamlet-Hamerly-Tonka loams, 1 to 3 percent slopes	19	IIc-6	37	--	--
	Hamlet part	19	-------	--	1	43
	Hamerly part	19	-------	--	1	43
	Tonka part	19	-------	--	2	43
HmA	Hamlet-Tonka loams, 1 to 3 percent slopes	19	IIc-6	37	--	--
	Hamlet part	19	-------	--	1	43
	Tonka part	19	-------	--	2	43
HoA	Hecla and Lohnes loamy sands, 1 to 3 percent slopes	19	IVe-2	39	--	43
	Hecla part	19	-------	--	1	43
	Lohnes part	19	-------	--	7	43
LaA	LaDelle silty clay loam, 1 to 3 percent slopes	20	IIc-6	37	1	43
LoB	Lohnes loamy sand, 3 to 6 percent slopes	20	IVe-2	39	7	43
Lu	Ludden silty clay	21	IIw-4	37	1	43
Ly	Ludden silty clay, very wet	21	Vw-4	40	10	44
Ma	Marsh	21	VIIIw-1	40	10	44
Mb	Marysland silt loam	22	IVw-4L	39	2	43
Pa	Parnell silty clay loam	23	IIIw-6	38	2	43
RnA	Renshaw loam, 1 to 3 percent slopes	24	IIIs-6	38	6	43
RnB	Renshaw loam, 3 to 6 percent slopes	24	IIIe-6	37	6	43
SoB	Sioux loam, 1 to 6 percent slopes	26	VIs-6	40	10	44
SoD	Sioux loam, 6 to 20 percent slopes	26	VIs-6	40	10	44
SvA	Svea loam, 1 to 3 percent slopes	26	IIc-6	37	1	43
SvB	Svea loam, 3 to 6 percent slopes	26	IIe-6	35	1	43
SwB	Svea loam, channeled, 1 to 6 percent slopes	27	VIe-6	40	3	43
SyA	Svea loam, fans, 1 to 3 percent slopes	27	IIc-6	37	1	43
SyB	Svea loam, fans, 3 to 6 percent slopes	27	IIe-6	35	1	43
SzA	Swenoda fine sandy loam, 1 to 3 percent slopes	28	IIIe-3	37	5	43
SzB	Swenoda fine sandy loam, 3 to 6 percent slopes	28	IIIe-3	37	5	43
Tf	Tiffany fine sandy loam	29	IIIw-5	38	2	43
To	Tonka silt loam	29	IIw-6	37	2	43
Va	Vallers loam	30	IIw-4L	37	2	43
Vb	Velva loam	30	IIe-5	35	1	43
Vd	Velva loam, channeled	30	VIe-6	40	1	43
WmA	Williams loam, 1 to 3 percent slopes	32	IIc-6	37	3	43
WmB	Williams loam, 3 to 6 percent slopes	32	IIe-6	35	3	43
WyA	Wyndmere fine sandy loam, 1 to 3 percent slopes	32	IIIe-3	37	1	43
ZaD	Zahl-Max loams, 9 to 15 percent slopes	33	VIe-5	40	--	--
	Zahl part	33	-------	--	8	43
	Max part	33	-------	--	3	43
ZaF	Zahl-Max loams, 15 to 60 percent slopes	33	VIe-5	40	--	--
	Zahl part	33	-------	--	8	43
	Max part	33	-------	--	3	43

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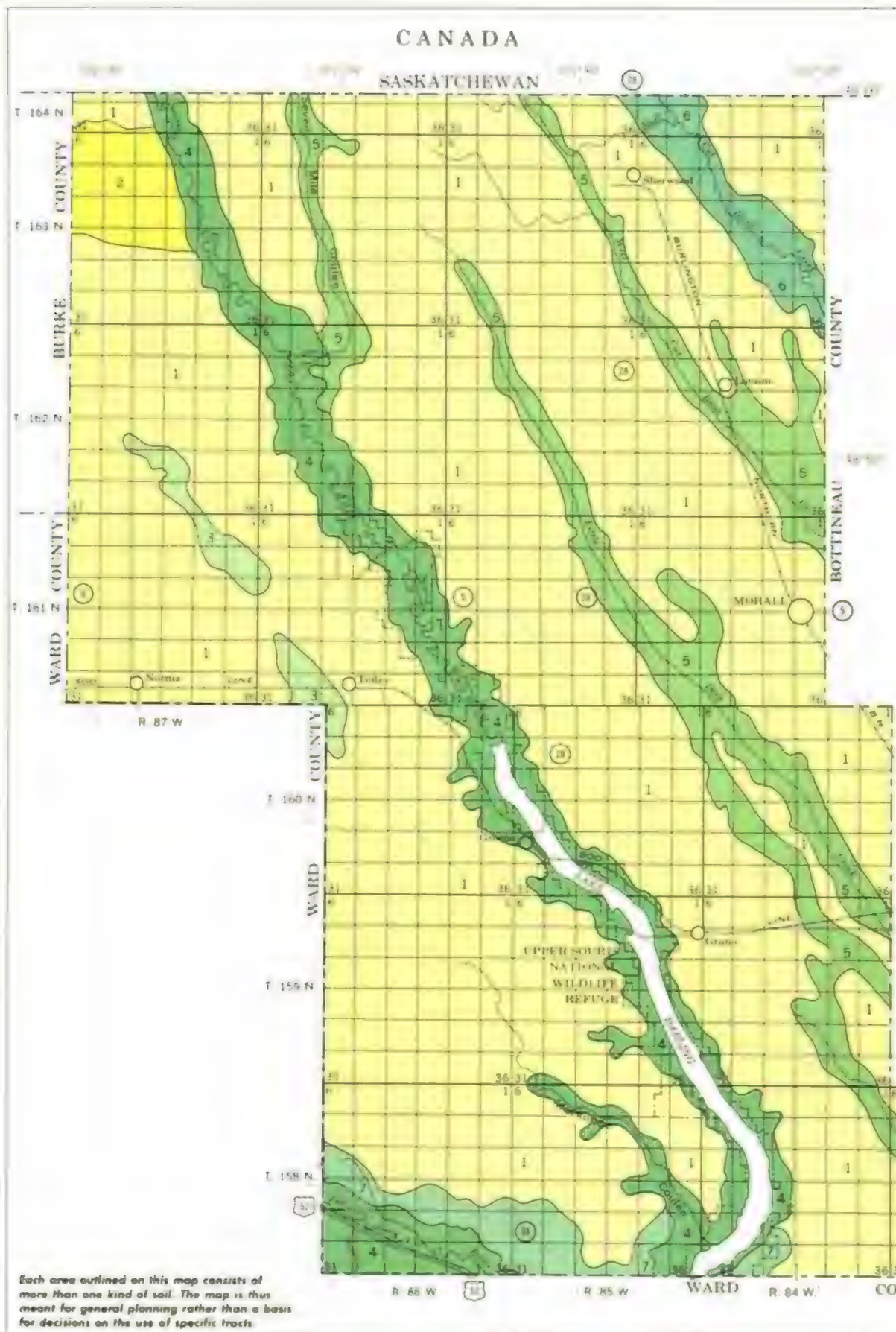

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

RENVILLE COUNTY, NORTH DAKOTA

Scale 1:253,440

0 1 2 3 4 Miles

SOIL ASSOCIATIONS

1 Barnes-Hamlet association: Nearly level, well drained and moderately well drained, medium textured soils on glacial till plains

2 Swenoda-Embden-Barnes association: Nearly level to undulating, moderately well drained and well drained, moderately coarse textured and medium textured soils on glacial till plains

3 Fargo-Great Bend association: Level and nearly level, poorly drained and well drained, fine textured and moderately fine textured soils in glacial lake basins

4 Zahl-Max association: Gently rolling to very steep, well drained, medium textured soils on side slopes of river valleys

5 Barnes-Colvin association: Nearly level, well drained, medium textured soils on glacial till plains and level, poorly drained, medium textured and moderately fine textured soils in narrow outwash channels

6 Arvilla-Renshaw-Colvin association: Level and nearly level, somewhat excessively drained and poorly drained, moderately coarse textured to moderately fine textured soils on gravel terraces and in outwash channels

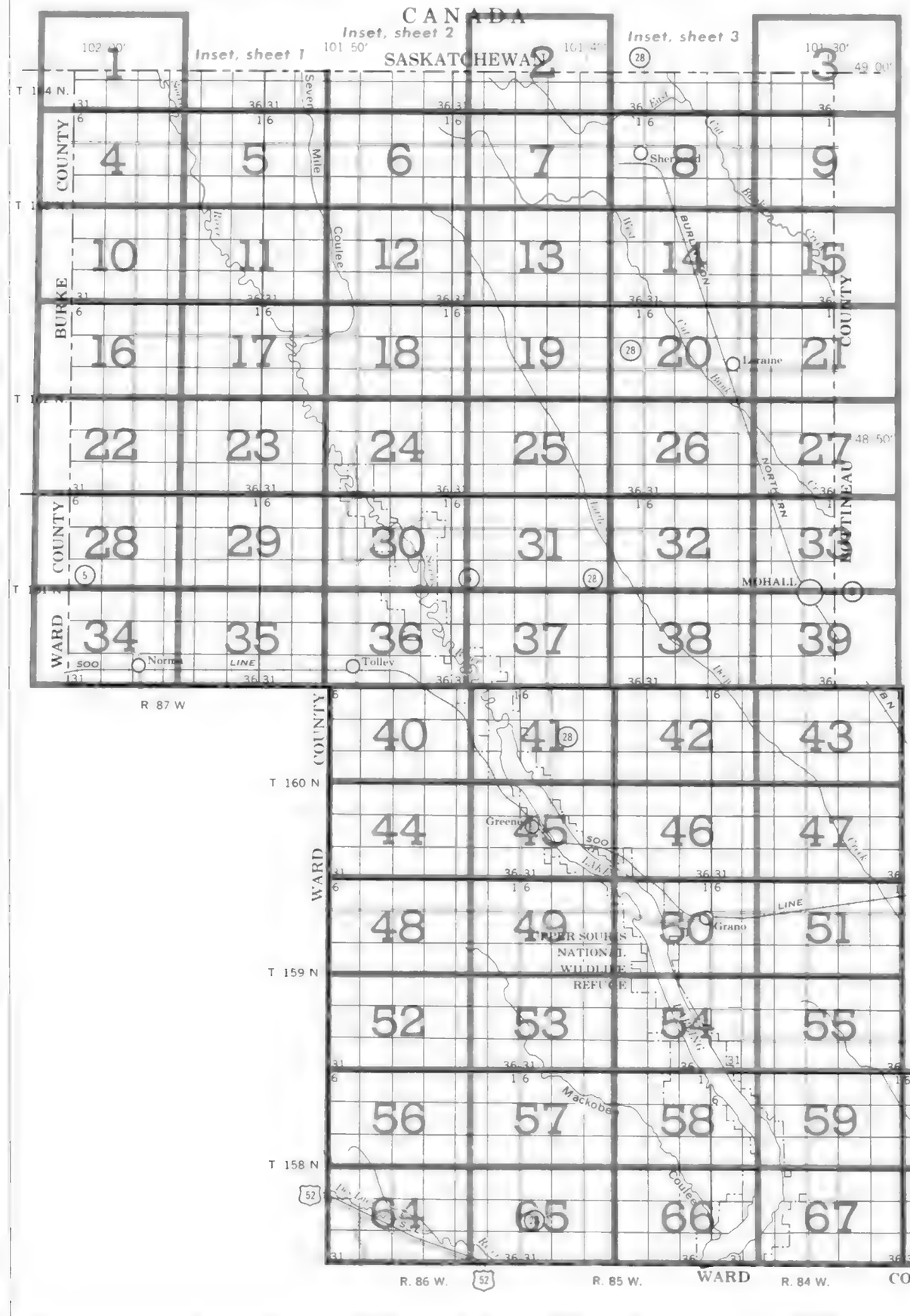
7 Barnes association: Undulating and nearly level, well drained, medium textured soils on glacial till plains

Compiled 1974

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36



N

INDEX TO MAP SHEETS

RENVILLE COUNTY, NORTH DAKOTA

Scale 1:253,440

1 0 1 2 3 4 Miles

Original text from each individual map sheet read:
This map is compiled on 1971 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

SOIL LEGEND

The first capital letter is the initial one of the soil name. The lower case letter that follows separates mapping units having names that begin with the same letter except that it does not separate sloping and eroded phases. The second capital letter indicates the class of slope. If all units of a series have slopes of 0 to 1 percent, the slope designation is omitted; or the symbol is for Gravel pits.

SYMBOL	NAME
A·	Arveson loam
A·C	Arvilla sandy loam, 6 to 9 percent slopes
A·A	Arvilla-Sioux sandy loams, 1 to 3 percent slopes
A·B	Arvilla-Sioux sandy loams, 3 to 6 percent slopes
BaA	Barnes loam, 1 to 3 percent slopes
BaB	Barnes loam, 3 to 6 percent slopes
BaC	Barnes loam, 6 to 9 percent slopes
BaD	Barnes loam, 9 to 12 percent slopes
BbB	Barnes cobbly loam, 1 to 6 percent slopes
BdB	Barnes Buse loams, 3 to 6 percent slopes
BdC	Barnes-Buse loams, 6 to 9 percent slopes
B·A	Barnes-Cresbard loams, 1 to 3 percent slopes
BgB	Barnes-Hamerly loams, 3 to 6 percent slopes
B·A	Barnes-Hamlet Tonka loams, 1 to 3 percent slopes
B·B	Barnes-Hamlet Tonka loams, 3 to 6 percent slopes
BhD	Barnes and Buse very stony loams, 3 to 15 percent slopes
CaA	Cavour-Cresbard loams, 1 to 3 percent slopes
Co	Colvin silt loam
Cp	Colvin soils, channeled
C·	Colvin soils, very wet
DdA	Divide loam, loamy substratum, 1 to 3 percent slopes
EmB	Embden sandy loam, 1 to 6 percent slopes
EoA	Embden Tiffany fine sandy loams, 1 to 3 percent slopes
Fa	Fargo silty clay
Fb	Fargo silty clay, very wet
F·	Fulda silty clay loam
Gp	Gravel pits
GrA	Great Bend silty clay loam, 1 to 3 percent slopes
HaA	Hamerly loam, 1 to 3 percent slopes
HbA	Hamerly Tonka loams, 1 to 3 percent slopes
HhA	Hamlet-Hamerly-Tonka loams, 1 to 3 percent slopes
HmA	Hamlet Tonka loams, 1 to 3 percent slopes
HsA	Hecla and Lohnes loamy sands, 1 to 3 percent slopes
LaA	LaDelle silty clay loam, 1 to 3 percent slopes
LoB	Lohnes loamy sand, 3 to 6 percent slopes
L·	Ludden silty clay
L,	Ludden silty clay, very wet
Ma	Marsh
Mb	Marysland silt loam
Pa	Parnell silty clay loam
R·A	Renshaw loam, 1 to 3 percent slopes
R·B	Renshaw loam, 3 to 6 percent slopes
SoB	Sioux loam, 1 to 6 percent slopes
SoD	Sioux loam, 6 to 20 percent slopes
S·A	Svea loam, 1 to 3 percent slopes
S·B	Svea loam, 3 to 6 percent slopes
S·B	Svea loam, channeled, 1 to 6 percent slopes
S,A	Svea loam, fans, 1 to 3 percent slopes
S,B	Svea loam, fans, 3 to 6 percent slopes
SzA	Swenoda fine sandy loam, 1 to 3 percent slopes
SzB	Swenoda fine sandy loam, 3 to 6 percent slopes
T·	Tiffany fine sandy loam
To	Tonka silt loam
V·	Vallers loam
V·	Velva loam
V·	Velva loam, channeled
WaA	Williams loam, 1 to 3 percent slopes
WaB	Williams loam, 3 to 6 percent slopes
WyA	Wyndmere fine sandy loam, 1 to 3 percent slopes
ZaD	Zahl-Max loams, 9 to 15 percent slopes
Z·E	Zahl-Max loams, 15 to 60 percent slopes

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Divided
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail
- Railroad
- Ferry
- Ford
- Grade
- R. R. over
- R. R. under

Buildings
- School
- Church

Mine and quarry

Gravel pit

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

Forest fire or lookout station

Windmill

Located object

BOUNDARIES

- National or state
- County
- Minor civil division
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Unclassified

Canals and ditches

Lakes and ponds
- Perennial
- Intermittent

Spring

Marsh or swamp

Wet spot

Drainage end or alluvial fan

RELIEF

Escarpments
- Bedrock
- Other

Short steep slope

Prominent peak

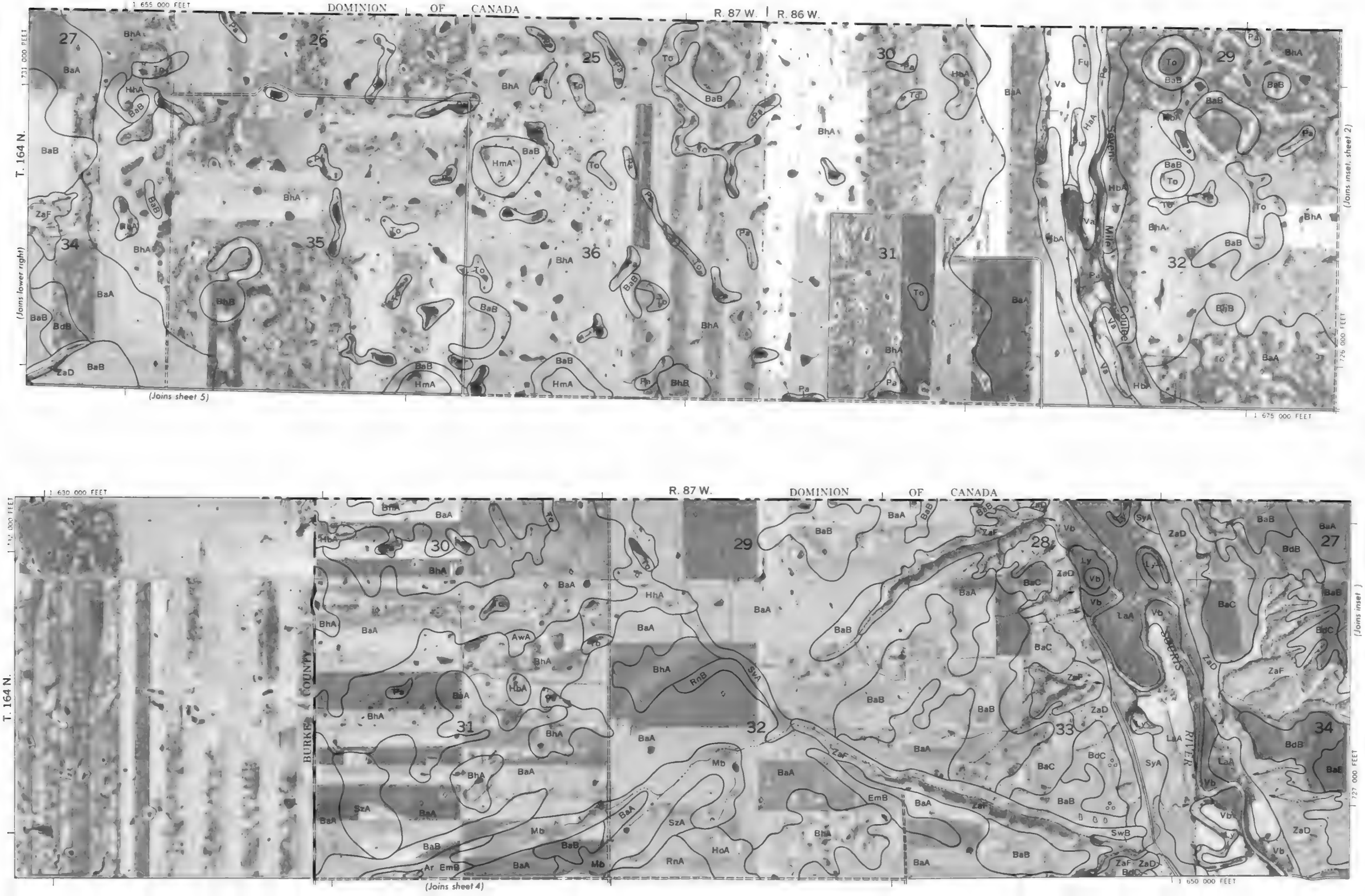
Depressions

	Large	Small
Crossable with tillage implements		
Not crossable with tillage implements		
Contains water most of the time		

SOIL SURVEY DATA

- Soil boundary and symbol
- Gravel
- Stoniness
  - Stony
  - Very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully
- Saline spot

RENVILLE COUNTY, NORTH DAKOTA – SHEET NUMBER 1



1 Mile
5 000 Feet
Scale 1:20 000

(2)

N

DOMINION OF CANADA

R 86 W | R. 85 W.

T. 164 N.

(Joins inset, sheet 1)

(Joins lower left)

(Joins sheet 6)

R 85 W

DOMINION OF CANADA

T. 164 N.

(Joins inset)

(Joins inset, sheet 3)

(Joins sheet 7)

Scale 1:20 000

1 Mile

5,000 Feet

RENVILLE COUNTY, NORTH DAKOTA – SHEET NUMBER 3

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 4

(4)

N

R. 87 W.

(Joins sheet 1)

1 650 000 FEET

725 000 FEET

T. 163 N.

BURKE COUNTY

ALTA

SOURIS RIVER

(Joins sheet 5)

(Joins sheet 10)

1 Mile

5 000 Feet

Scale 1:20 000

0 1 000 2 000 3 000 4 000 5 000 FEET

1 650 000 FEET

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 5

1 655 000 FEET

R. 87 W. | R. 86 W.

(Joins inset, sheet 1)

T. 163 N.

(Joins sheet 4)

(Joins sheet 6)

(Joins sheet 11)

1 675 000 FEET

710 000 FEET

SOURIS RIVER

Seven Mile Coulee

5

N

1 Mile

5 000 Feet

Scale 1:20 000


6
N
(Joins inset, sheet 2)
R. 86 W.
R. 85 W.
(Joins sheet 5)
(Joins sheet 7)
(Joins sheet 12)
T. 163 N.
1 680 000 FEET
1
2
3
4
6
9
10
11
12
13
14
15
16
18
West Cut Bank Creek
1 Mile
5 000 Feet
Scale 1:20 000
0
1/4
1/2
3/4
1
1 000
2 000
3 000
4 000
5 000

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 7

7

N

R. 85 W.

1 705 000 FEET

(Joins sheet 2)

T. 163 N.

1 720 000 FEET

(Joins sheet 6)

(Joins sheet 8)

(Joins sheet 13)

Bank Creek

Cut Bank Creek

West Cut Bank Creek

UNION CEMETERY

1 Mile

5 000 Feet

Scale 1:20 000

(8)

N

R. 85 W. | R. 84 W.

(Joins inset, sheet 3)

1 745 000 FEET

T. 163 N.

(Joins sheet 7)

(Joins sheet 9)

(Joins sheet 14)

1 710 000 FEET

1 Mile 5 000 Feet

Scale 1:20 000

Sherwood

MUNICIPAL PARK

LAGOON

BURLINGTON NORTHERN

Cut Bank Creek

Bank Creek


(Joins sheet 3)
R. 84 W.
T. 163 N.
(Joins sheet 8)
(Joins sheet 15)
BOTTINEAU COUNTY
9
N
1 Mile
5 000 Feet
Scale 1:20 000
0
1/4
1/2
3/4
1
1 000
2 000
3 000
4 000
5 000
770 000 FEET
Cut Bank
SoB Cr
BaA
BhA
HbA
HaA
HhA
HmA
HoA
SzA
EmB
WyA
HbA
Pa
Va
Cr
Ar
AwA
DdA
LoB
Mb
To
Pe
Ba
SvA

(10)

N

1 Mile 5 000 Feet

Scale 1:20 000

0 0

¼ 1 000

½ 2 000

¾ 3 000

1 4 000

5 000

(Joins sheet 4)

R. 87 W.

650 000 FEET

705 000 FEET

T. 163 N.

BURKE COUNTY

19 20 21 22

30 29 28 27

31 32 33 34

PLEASANT VIEW CEMETERY

Pleasant View Church

630 000 FEET

(Joins sheet 16)

(Joins sheet 11)

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 11

R. 87 W. | R. 86 W.

(Joins sheet 5)

T. 163 N.

(Joins sheet 10)

(Joins sheet 12)

(Joins sheet 17)

1 655 000 FEET

1 675 000 FEET

SOURIS RIVER

Seven Mile Coulee

11

N

1 Mile 5 000 Feet

Scale 1:20 000

N

(Joins sheet 6)

R. 86 W. | R. 85 W.

1 700 000 FEET

1 Mile

5 000 Feet

Scale 1:20 000

0 ¼ ½ ¾ 1

1 000 2 000 3 000 4 000 5 000

(Joins sheet 11)

1 705 000 FEET

T. 163 N.

(Joins sheet 13)

(Joins sheet 18)

1 680 000 FEET

Seven Mile Coulee

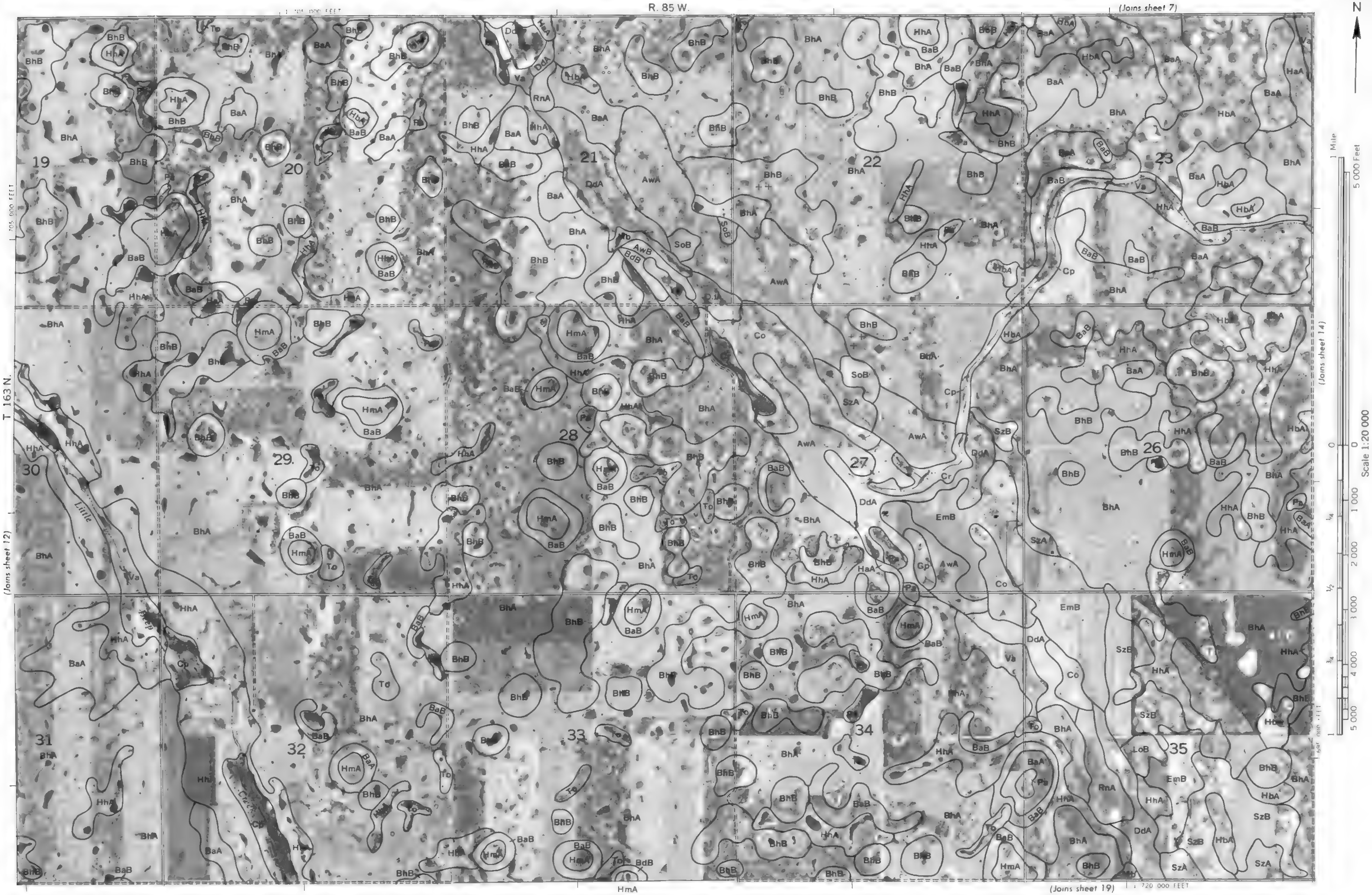
Little Deep Creek

21 22 23 24 19

28 27 26 25 30

33 34 35 36 31

BhB BhA BaB BaA HhA HmA HbA Pa To GrA BdB SvA HaA SzB


R. 85 W.
(Joins sheet 7)
T. 163 N.
(Joins sheet 12)
(Joins sheet 14)
(Joins sheet 19)
N
1 Mile
5 000 Feet
Scale 1:20 000
19
20
21
22
23
26
27
28
29
30
31
32
33
34
35
Little
Deep
Creek
720 000 FEET
HmA

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 14

(14)

N

R. 85 W. | R. 84 W.

(Joins sheet 8)

1 Mile

5 000 Feet

Scale 1:20 000

0 0 1 000 2 000 3 000 4 000 5 000

1 145 000 FEET

T. 163 N.

(Joins sheet 13)

(Joins sheet 15)

(Joins sheet 20)

1 725 000 FEET

19 20 21 22

24 25 30 29 28 27

36 31 32 33 34

Burlington Northern

Bank Creek

(Joins sheet 9)

R. 84 W.

T. 163 N.

(Joins sheet 14)

(Joins sheet 21)

BOTTINEAU COUNTY

22 23 24 25 26 27 34 35 36

East Cut Bank Creek

AwA AwB BaA BaB BhA DdA EmB HaA HbA HhA HoA LoB Mb SoB SwA SzA SzB WyA Ar Co Pa To

15

N

1 Mile

5 000 Feet

Scale 1:20 000

16

N

(Joins sheet 10)

R 87 W.

T 162 N

BURKE COUNTY

Scale 1:20 000

1 Mile 5 000 Feet

0 0

1/4 1/2 3/4 1

5 000 4 000 3 000 2 000 1 000

(Joins sheet 22)

(Joins sheet 17)

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 17

17

N

R. 87 W. | R. 86 W.

(Joins sheet 11)

T. 162 N.

(Joins sheet 16)

(Joins sheet 18)

(Joins sheet 23)

1 675 000 FEET

650 000 FEET

SOURIS RIVER

Seven Mile Coulee

1 Mile

5 000 Feet

Scale 1:20 000

(18)

N

(Joins sheet 12)

1 695 000 FEET R. 86 W. | R. 85 W.

T. 162 N.

(Joins sheet 19)

(Joins sheet 17)

(Joins sheet 24)

Scale 1:20 000

1 Mile 5 000 Feet

Coulee

Mile

Seven

4 3 2 1 6

9 10 11 12 7

16 15 14 13 18

BaA BaB BhA BhB HbA HhA HmA Pa To ZaF BnD Fu GrA

N

1 700 000 FEET

R. 85 W.

(Joins sheet 13)

T. 162 N.

(Joins sheet 18)

(Joins sheet 20)

(Joins sheet 25)

1 700 000 FEET

1 720 000 FEET

1 Mile 5 000 Feet 0 0

Scale 1:20 000

1 5 000 ¾ 4 000 ½ 3 000 ¼ 2 000 1 000 0

Homerly Church

Cp Creek

(20)

N

(Joins sheet 14) R. 85 W | R. 84 W.

1 745 000 FEET

T. 162 N

690 000 FEET

1 Mile 5 000 Feet

Scale 1:20 000

1 000 0 1 000 2 000 3 000 4 000 5 000

(Joins sheet 19)

(Joins sheet 21)

(Joins sheet 26)

1 735 000 FEET

West Burt Creek

Cut Creek

BURLINGTON NORTHERN

Loraine

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 21

21

N

1 750 000 FEET

(Joins sheet 15)

R. 84 W.

1 680 000 FEET

T. 162 N.

BOTTINEAU COUNTY

(Joins sheet 20)

(Joins sheet 27)

1 770 000 FEET

1 Mile 5 000 Feet

Scale 1:20 000

0 0

¼ 1 000

½ 2 000

¾ 3 000

1 4 000

5 000

(22)

N

(Joins sheet 16)

R. 87 W.

1 650 000 FEET

T. 162 N.

1 Mile

5 000 Feet

Scale 1:20 000

0 0

1/4 1/2 3/4 1

1 000 2 000 3 000 4 000 5 000

1 650 000 FEET

BURKE COUNTY

19 20 21 22

30 29 28 27

31 32 33 34

BaA BaB BdB BfA BhA BhB CaA Fa Fu GrA HaA HbA HhA HmA Pa SvA SzA To

(Joins sheet 28)

(Joins sheet 23)

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 23

R. 87 W. | R. 86 W.

T. 162 N.

(Joins sheet 17)

(Joins sheet 22)

(Joins sheet 24)

(Joins sheet 29)

1 675 000 FEET

Evanger Church

SOURIS RIVER

23

N

1 Mile

5 000 Feet

0 0

Scale 1:20 000

1 000 ½ 2 000 3 000 ¾ 4 000 5 000

(24)

N

(Joins sheet 18)

1 695 000 FEET R. 86 W. | R. 85 W.

T. 162 N.

(Joins sheet 25)

(Joins sheet 23)

(Joins sheet 30)

1 Mile

5 000 Feet

Scale 1:20 000

0 4 000 3 000 2 000 1 000 0

UPPER SOURIS NATIONAL WILDLIFE REFUGE

SOURIS RIVER

21 22 23 24 19 28 27 26 25 30 33 34 35 36 31

BaA BaB BaC BbB BdB BdC BhA BhB GrA HaA HbA HhA HmA Lu LaA Pa SvA SwB SyA SyB To Vb ZaD ZaF

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 25

25

N

R. 85 W.

(Joins sheet 19)

1 720 000 FEET

675 000 FEET

T. 162 N.

(Joins sheet 24)

(Joins sheet 26)

(Joins sheet 31)

1 Mile
5 000 Feet
Scale 1:20 000

(26)

N

R. 85 W. | R. 84 W.

(Joins sheet 20)

1 745 000 FEET

T. 162 N.

(Joins sheet 25)

(Joins sheet 27)

1 Mile
5 000 feet
Scale 1:20 000
0
1 000
2 000
3 000
4 000
5 000

24 19 20 21 22
25 30 29 28 27
36 31 32 33 34

Burlington Northern Cut Bank Creek

1 725 000 FEET

(Joins sheet 32)

(Joins sheet 21)

R. 84 W.

T. 162 N.

(Joins sheet 26)

(Joins sheet 33)

BOTTINEAU COUNTY

675 000 FEET

770 000 FEET

665 000 FEET

27

N

1 Mile

5 000 Feet

Scale 1:20 000

0 ¼ ½ ¾ 1

0 1 000 2 000 3 000 4 000 5 000

Creek

Bank

Cut

West

BURLINGTON NORTHERN

(28)

N

R. 87 W.

(Joins sheet 22)

1 : 250 000 FEET

1 Mile

5 000 Feet

Scale 1 20 000

1 000 FEET

T. 161 N.

WARD COUNTY

(Joins sheet 29)

(Joins sheet 34)

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 29

R. 87 W. | R. 86 W.

29

N

(Joins sheet 23)

T. 161 N.

(Joins sheet 28)

(Joins sheet 30)

(Joins sheet 35)

1 675 000 FEET

1 Mile

5 000 feet

Scale 1:20 000

0 1 000 2 000 3 000 4 000 5 000

30

N

R. 86 W. | R. 85 W.

T. 161 N.

(Joins sheet 24)

(Joins sheet 29)

(Joins sheet 31)

(Joins sheet 36)

1 695 000 FEET

1 680 000 FEET

SOURIS RIVER

MOUSE RIVER PARK

UPPER SOURIS NATIONAL WILDLIFE REFUGE

Scale 1:20 000

1 Mile 5 000 Feet

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 31

R. 85 W.

T. 161 N.

(Joins sheet 25)

(Joins sheet 30)

(Joins sheet 32)

(Joins sheet 37)

31

N

1 Mile

5 000 Feet

Scale 1:20 000

0 1 000 2 000 3 000 4 000 5 000

N

(Joins sheet 26)

R. 85 W. | R. 84 W.

1 745 000 FEET

T. 161 N.

1 Mile

5 000 Feet

Scale 1:20 000

(Joins sheet 31)

(Joins sheet 33)

(Joins sheet 38)

1 750 000 FEET

1 745 000 FEET

1 Little Deep Creek

1 Little Deep Creek

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 33

33

N

(Joins sheet 27)

R. 84 W.

1 750 000 FEET

T. 161 N.

(Joins sheet 32)

(Joins sheet 39)

COUNTY

BOTTINEAU

1 770 000 FEET

1 645 000 FEET

1 Mile

5 000 Feet

Scale 1:20 000

Mohall

MOHALL AIRPORT

NORTHERN

BURLINGTON

West Cp

Cut Bank Cp

Creek

BhA BhB BaA BaB HbA HhA HmA BdB SoB AwA EmB HaA Co RnA GrA To Pa BbB

(34)

N

R. 87 W.

(Joins sheet 28)

1 650 000 FEET

T. 161 N.

1 Mile

5 000 Feet

Scale 1 20 000

0 ½ 1 000 2 000 3 000 4 000

1 650 000 FEET

WARD COUNTY

WARD COUNTY

(Joins sheet 35)

19 20 21 22

30 29 28 27

31 32 33 34

Norma

LINE

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 35

R. 87 W. | R. 86 W.

(Joins sheet 29)

T. 161 N

(Joins sheet 34)

(Joins sheet 36)

WARD COUNTY

1 Mile

5,000 Feet

Scale 1:20 000

(36)

N

R. 86 W. | R. 85 W.

1 695 000 FEET

645 000 FEET

T. 161 N.

(Joins sheet 30)

(Joins sheet 35)

(Joins sheet 37)

(Joins sheet 40)

WARD CO

Scale 1:20 000

1 Mile

5 000 Feet

Tolley

SOURIS RIVER

UPPER SOURIS NATIONAL WILDLIFE REFUGE

SOO LINE

21 22 23 24 19

28 27 26 25 30

33 34 35 36 31

BaA BaB BaC BaD BdB BdC BhA BhB GrA HbA HhA HmA Ma SoB SvA SwB SyA SyB ZaD ZaF

R. 85 W

(Joins sheet 31)

T. 161 N.

(Joins sheet 36)

(Joins sheet 38)

UPPER SOURIS NATIONAL WILDLIFE REFUGE

SOURIS RIVER

(40) (Joins sheet 41)

N

1 Mile

5 000 Feet

Scale 1:20 000

N

Scale 1:20 000

1 Mile 5 000 Feet

(Joins sheet 32) R. 85 W | R. 84 W.

1 745 000 FEET

645 000 FEET

T. 161 N.

(Joins sheet 37)

(Joins sheet 39)

1 630 000 FEET

(41) (Joins sheet 42)

1 725 000 FEET

(Joins sheet 33)

1 750 000 FEET

R. 84 W.

Mohall

BURLINGTON NORTHERN

T. 161 N.

COUNTY

BOTTINEAU

(Joins sheet 38)

(42) | (Joins sheet 43)

1 770 000 FEET

39

N

1 Mile

5 000 Feet

Scale 1:20 000

0 0

¼ 1 000

½ 2 000

¾ 3 000

1 4 000 5 000

6 560 000 FEET

(40)

N

R. 86 W.

(Joins sheet 36) (37)

WARD COUNTY

T. 160 N.

UPPER SOURIS NATIONAL WILDLIFE REFUGE

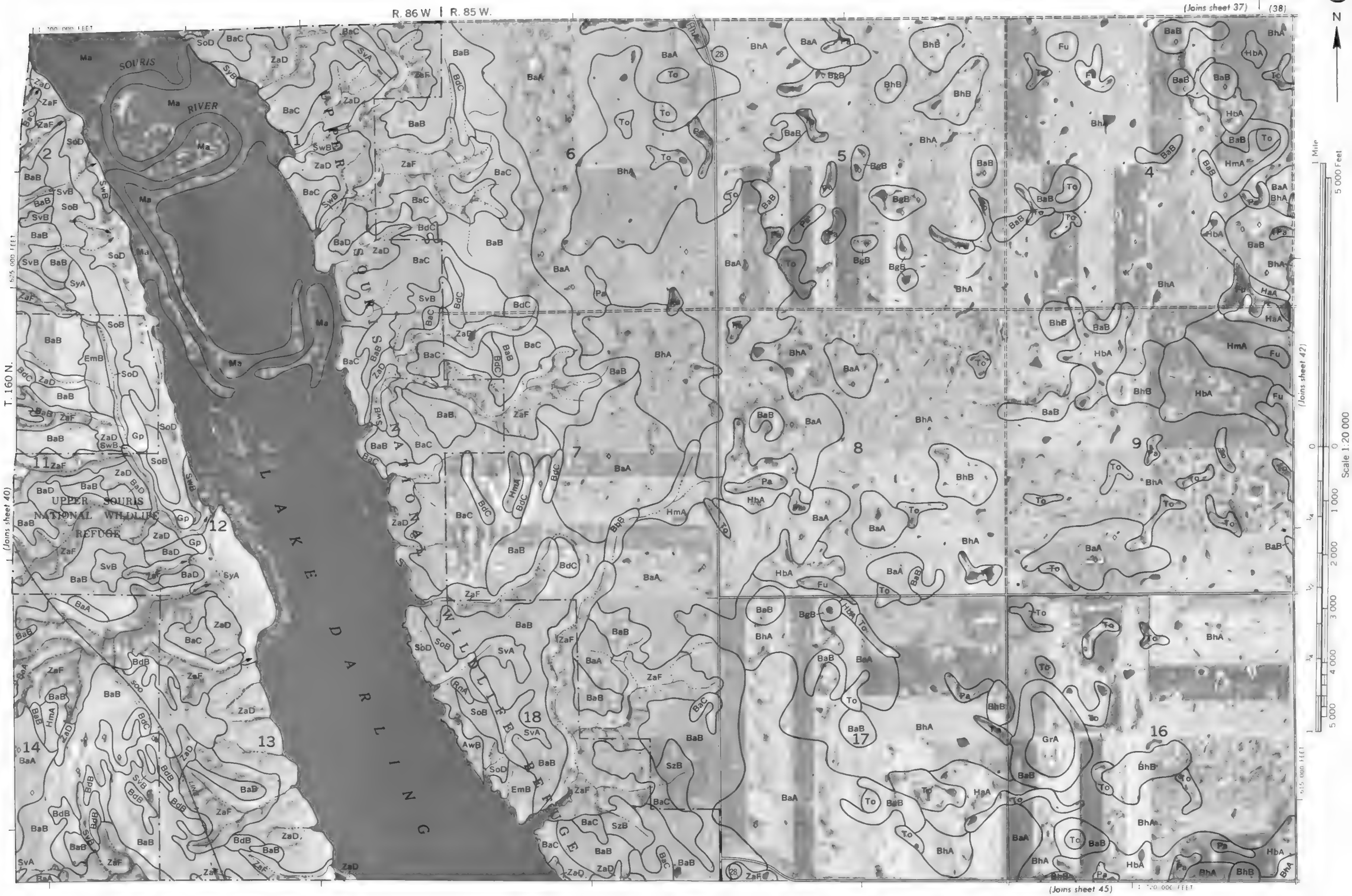
Scale 1:20 000

1 Mile

5 000 feet

(Joins sheet 41)

(Joins sheet 44)


R. 86 W.
R. 85 W.
(Joins sheet 37)
(38)
N
T. 160 N.
(Joins sheet 40)
(Joins sheet 42)
(Joins sheet 45)
Scale 1:20 000
1 Mile
5 000 Feet
SOURIS RIVER
UPPER SOURIS NATIONAL WILDLIFE REFUGE
LAKE DARLING
1
2
4
5
6
7
8
9
11
12
13
14
16
17
18
28

N

R. 85 W. | R. 84 W.

1 745 000 FEET

(Joins sheet 38) | (39)

1 Mile

5 000 Feet

0 0

Scale 1:20 000

¼ 1 000

½ 2 000

¾ 3 000

1 4 000

5 000

(Joins sheet 41)

1 625 000 FEET

T. 160 N.

(Joins sheet 43)

1 625 000 FEET

(Joins sheet 46)

N

1 750 000 FEET

(Joins sheet 39)

R. 84 W.

BOTTINEAU COUNTY

T 160 N.

(Joins sheet 42)

(Joins sheet 47)

1 625 000 FEET

1 770 000 FEET

BURLINGTON NORTHERN

Little Deep Creek

1 Mile

5 000 Feet

Scale 1:20 000

BOTTINEAU COUNTY

(44)

N

(Joins sheet 40)

R. 86 W.

1 695 000 FEET

1 Mile

5 000 Feet

Scale 1:20 000

WARD COUNTY

T. 160 N.

1 680 000 FEET

(Joins sheet 45)

(Joins sheet 48)

1 680 000 FEET

R. 86 W. | R. 85 W.

T 160 N

(Joins sheet 41)

(Joins sheet 44)

(Joins sheet 46)

(Joins sheet 49)

LAKE

SOURIS NATIONAL WILDLIFE REFUGE

DARLING

Greene

N

1 Mile

5 000 Feet

Scale 1:20 000

(Joins sheet 42)

R. 85 W. | R. 84 W.

T 160 N

(Joins sheet 45)

(Joins sheet 47)

(Joins sheet 50)

N

1 Mile

5 000 Feet

Scale 1:25 000

LAKE DARLING

UPPER SOURIS NATIONAL WILDLIFE REFUGE

22 23 24 19 20

27 26 25 30 29

34 35 36 31 32

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 47

47

N

R. 84 W.

(Joins sheet 43)

T. 160 N.

(Joins sheet 46)

(Joins sheet 51)

20 21 22 23 24

29 28 27 26 25

32 33 34 35 36

Little Deep Creek

BOTTINEAU COUNTY

1 Mile

5 000 Feet

Scale 1:20 000

0 1/4 1/2 3/4 1

0 1 000 2 000 3 000 4 000 5 000

(48)

N

(Joins sheet 44)

R. 86 W.

T. 159 N.

(Joins sheet 49)

(Joins sheet 52)

1 595 000 FEET

1 580 000 FEET

1 Mile 5 000 Feet

Scale 1:20 000

WARD COUNTY

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 49

49

N

R. 86 W. | R. 85 W.

(Joins sheet 45)

T. 159 N.

(Joins sheet 48)

(Joins sheet 50)

(Joins sheet 53)

LAKE DARLING

UPPER SOURIS NATIONAL WILDLIFE REFUGE

1 720 000 FEET

1 Mile

5 000 Feet

Scale 1:20 000

50

N

R. 85 W. | R. 84 W.

1 745 000 FEET

(Joins sheet 46)

(Joins sheet 49)

(Joins sheet 51)

(Joins sheet 54)

T. 159 N.

LAKE DARLING

SOURIS NATIONAL WILDLIFE REFUGE

SOO LINE

Grano

1 Mile

5 000 feet

Scale 1:20 000

0 0 ¼ ½ ¾ 1

1 000 2 000 3 000 4 000 5 000 FEET

R. 84 W

(Joins sheet 47)

T. 159 N

(Joins sheet 50)

(Joins sheet 55)

N

1 Mile 5 000 Feet

BOTTINEAU COUNTY

Scale 1:20 000

0 1/4 1/2 3/4 1 1 000 2 000 4 000 6 000

N

(Joins sheet 48)

R. 86 W.

1 695 000 FEET

T. 159 N.

(Joins sheet 53)

1 Mile 5 000 Feet

Scale 1:20 000

WARD COUNTY

1 380 000 FEET

(Joins sheet 56)

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 53

53

N

R. 86 W. | R.85 W.

T. 159 N

(Joins sheet 49)

(Joins sheet 54)

(Joins sheet 52)

(Joins sheet 57)

Mackobee Coulee

1 Mile 5 000 Feet

Scale 1:20 000

N

R 85 W | R 84 W

T. 159 N

(Joins sheet 50)

(Joins sheet 53)

(Joins sheet 55)

(Joins sheet 58)

1 Mile

5 000 Feet

Scale 1:20 000

1 000 0 1 000 2 000 3 000 4 000 5 000

22 23 24 19 20

27 26 25 30 29

34 35 36 31 32

UPPER SOURIS NATIONAL WILDLIFE REFUGE

LAKE DARLING

BaA BaB BdB BdC BhA BhB BnD HaA HbA HhA HmA Po SvA SwB SzA SzB To ZaD ZaF

N

R. 84 W.

(Joins sheet 51)

T. 159 N.

(Joins sheet 54)

(Joins sheet 59)

BOTTINEAU COUNTY

Scale 1:20 000

1 Mile

5,000 Feet

(56)

N

(Joins sheet 52)

R. 86 W.

1 695 000 FEET

565 000 FEET

T. 158 N.

1 Mile

5 000 Feet

Scale 1:20 000

WARD COUNTY

555 000 FEET

(Joins sheet 57)

(Joins sheet 64)

Carr Feldner Coulee

RENVILLE COUNTY, NORTH DAKOTA – SHEET NUMBER 57

57

R. 86 W. | R. 85 W.

(Joins sheet 53)

T 158 N.

(Joins sheet 56)

(Joins sheet 58)

(Joins sheet 65)

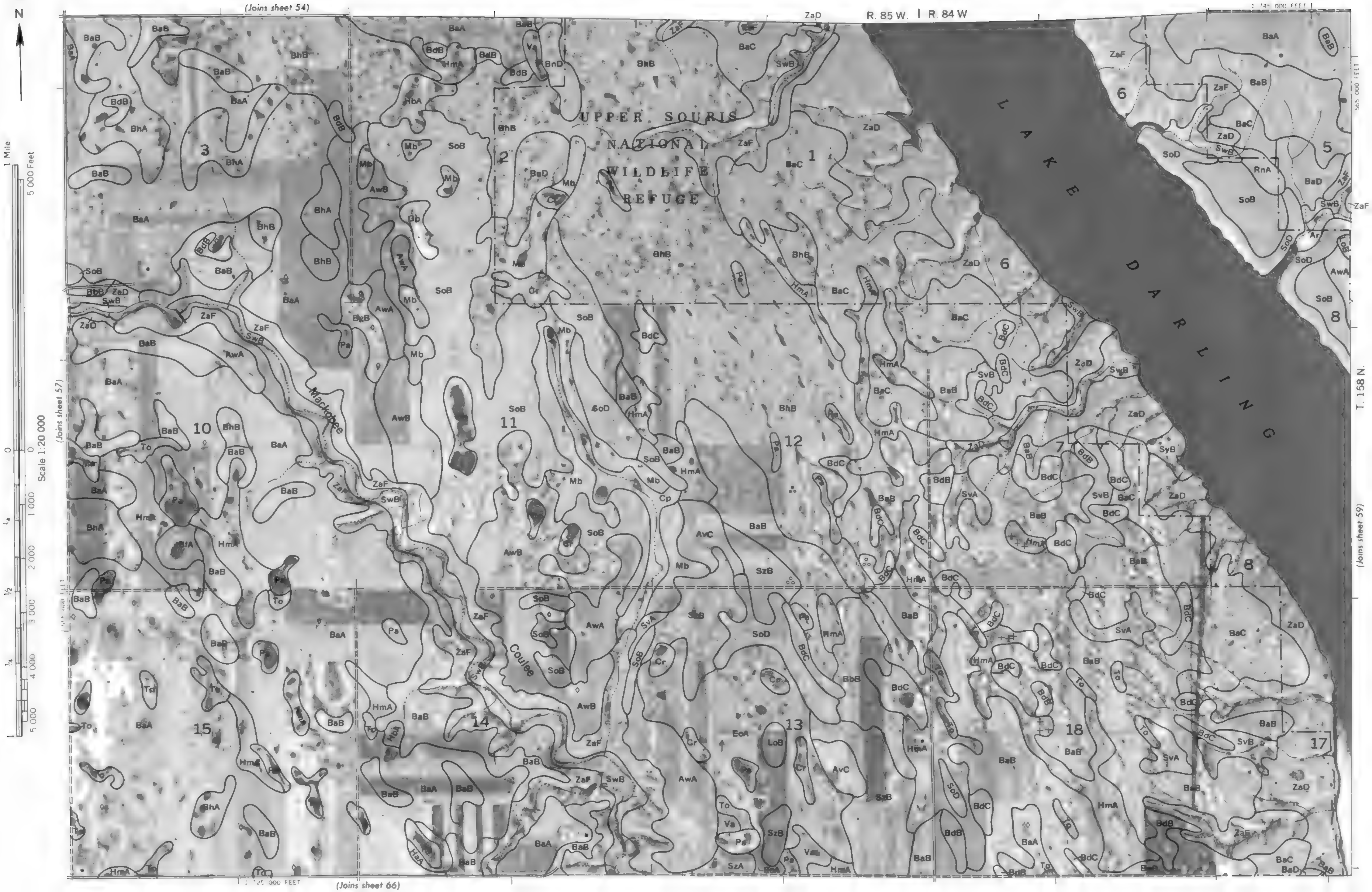
Mackobee Coulee

N

1 Mile

5 000 Feet

Scale 1:20 000


N
(Joins sheet 54)
(Joins sheet 57)
(Joins sheet 59)
(Joins sheet 66)
R. 85 W. | R. 84 W.
T. 158 N.
UPPER SOURIS NATIONAL WILDLIFE REFUGE
LAKE DARLING
Mackobee Coulee
1 Mile
5 000 Feet
Scale 1:20 000
0
1/4
1/2
3/4
1
1 000
2 000
3 000
4 000
5 000
1 745 000 FEET
565 000 FEET
1 725 000 FEET

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 59

59

N

R. 84 W.

(Joins sheet 55)

T. 158 N.

(Joins sheet 58)

(Joins sheet 60)

(Joins sheet 67)

565 000 FEET

550 000 FEET

765 000 FEET

UPPER SOURIS NATIONAL WILDLIFE REFUGE

LAKE DARLING

1 Mile

5 000 Feet

Scale 1:20 000

0 ¼ ½ ¾ 1

0 1 000 2 000 3 000 4 000 5 000

BOTTINEAU COUNTY

R. 83 W.

T. 158 N.

N

Scale 1:20 000

1 Mile

5,000 Feet

(Joins sheet 59)

(Joins sheet 61)

(Joins sheet 68)

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 61

61

N

R. 83 W. | R. 82 W.

BOTTINEAU COUNTY

T 158 N.

(Joins sheet 60)

(Joins sheet 62)

(Joins sheet 69)

Scale 1:20 000

1 Mile

5 000 feet

62

N

BOTTINEAU COUNTY

R. 82 W. | R. 81 W.

T. 158 N.

Glenburn

Spring Coulee

BURLINGTON NORTHERN

(Joins sheet 61)

(Joins sheet 63)

(Joins sheet 70)

1 820 000 FEET

1 560 000 FEET

1 Mile

5 000 Feet

0

Scale 1:20 000

1 000 2 000 3 000 4 000

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 63

63

N

1 845 000 FEET

R. 81 W.

BOTTINEAU COUNTY

Our Savior Church

T 158 N

(Joins sheet 62)

(Joins sheet 71)

MCHENRY COUNTY

1 Mile

5 000 Feet

Scale 1:20 000

550 000 FEET

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 64

(64)

N

1 Mile
5 000 Feet
Scale 1:20 000
0 0
1 000 2 000 3 000 4 000 5 000

(Joins sheet 56)

R. 86 W.

1 695 000 FEET

550 000 FEET

T. 158 N.

(Joins sheet 65)

WARD COUNTY

1 540 000 FEET

1 675 000 FEET

WARD COUNTY

Carl Feldner Coulee

Des Lacs River

Soo Line

52

19 20 21 22 23
30 29 28 27 26
31 32 33 34 35

ZaF ZaD BbB BaB BaA BaC BhA BhB HmA HbA To Pa Vb Vd Lu SyA SyB SwB WmB WmA

N

R. 86 W. | R. 85 W.

T. 158 N.

(Joins sheet 57)

(Joins sheet 64)

(Joins sheet 66)

1 : 720 000 FEET

1 Mile
5 000 Feet
Scale 1:20 000
0 ¼ ½ ¾ 1 000 2 000 3 000 4 000 5 000

WARD COUNTY

66

N

(Joins sheet 58)

R. 85 W. | R. 84 W.

T. 158 N.

(Joins sheet 65)

(Joins sheet 67)

1 Mile 5 000 Feet

Scale 1:20 000

HELSETH DAM

Mackobee Coulee

UPPER SOURIS NATIONAL WILDLIFE REFUGE

LAKE DARLING

WARD COUNTY

R. 84 W.

(Joins sheet 59)

1 750 000 FEET

545 000 FEET

T 158 N.

(Joins sheet 66)

(Joins sheet 68)

WARD COUNTY

1 765 000 FEET

N

1 Mile

5 000 Feet

Scale 1:20 000

0 ¼ ½ ¾ 1

5 000 4 000 3 000 2 000 1 000 0

LAKE DARLING

SOURIS-PLAINS NATIONAL WILDLIFE REFUGE

St Henrys Church

ST HENRYS CEMETERY

21 22 23 24

28 27 26 25

29 34 35 36

32 33

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 68

(68)

N

R. 83 W.

1 790 000 FEET

545 000 FEET

T. 158 N.

(Joins sheet 60)

(Joins sheet 67)

(Joins sheet 69)

1 770 000 FEET

535 000 FEET

WARD COUNTY

1 Mile

5 000 Feet

Scale 1:20 000

0 0 ¼ ½ ¾ 1

1 000 2 000 3 000 4 000 5 000

19 20 21 22 23

30 29 28 27 26

31 32 33 34 35

Creek

1 795 000 FEET

R. 83 W. | R. 82 W.

(Joins sheet 61)

1 545 000 FEET

T. 158 N.

(Joins sheet 70)

(Joins sheet 68)

1 535 000 FEET

1 815 000 FEET

WARD COUNTY

N

1 Mile

5 000 Feet

Scale 1:20 000

0 1 000 2 000 3 000 4 000 5 000

0 ¼ ½ ¾ 1

N

(Joins sheet 62)

R. 82 W.

R. 81 W.

1 840 000 FEET

545 000 FEET

T. 158 N.

(Joins sheet 69)

(Joins sheet 71)

1 Mile

5 000 Feet

Scale 1:20 000

515 000 FEET

1 820 000 FEET

WARD COUNTY

Little Deep Creek

BURLINGTON NORTHERN

RENVILLE COUNTY, NORTH DAKOTA — SHEET NUMBER 71

71

N

1 845 000 FEET

R. 81 W.

(Joins sheet 63)

1 545 000 FEET

T. 158 N.

(Joins sheet 70)

Spring Coulee

Spring Coulee

1 860 000 FEET

WARD COUNTY

McHENRY COUNTY

1 535 000 FEET

1 Mile

5 000 Feet

Scale 1:20 000